XXXII.—A REPORT ON THE HISTORY AND PRESENT CONDITION OF THE SHORE COD-FISHERIES OF CAPE ANN, MASS., TOGETHER WITH NOTES ON THE NATURAL HISTORY AND ARTIFICIAL PROPAGATION OF THE SPECIES.

By R. E. Earll.

A.—INTRODUCTION.

The recent inquiry into the decrease of the food-fishes of the east coast of the United States by the United States Commission of Fish and Fisheries, under the direction of the commissioner, Prof. Spencer F. Baird, has led to the establishment of temporary stations at different points along the coast, where special attention has been given to the study of the more important species for the purpose of gathering definite information of their relative numbers past and present, their geographical distribution, and their habits. Of late the commercial importance of what might be styled the great ocean fisheries, together with the complicated questions that are continually arising between our own government and our more northern neighbor regarding them, has led Professor Baird to give particular attention to this subject, with a view to becoming more thoroughly acquainted, not only with the habits and movements of these species, but also the methods employed in their capture and the extent and money-value of the fisheries.

With this end in view, he selected Gloucester, Mass., as the most suitable location for the Commission in 1878, where he arrived with his assistants early in July, and at once began the investigation of the subject. During the summer much valuable information was gathered relating to the extent of the fisheries, and many observations were made on the natural history of the different species. However, as this was not the spawning season for the different members of the cod family, the only obtainable information on the habits of the fish during this period was from the fishermen, who are usually not considered very accurate scientific observers.

After a careful consideration of the subject, it was decided to continue the station through the winter, in order to study the natural history of the spawning fish, that visit the shore in immense numbers at this time, and also to make experiments with the eggs of the cod and other species, with a view to their artificial propagation. Accordingly, the late James W. Milner, deputy commissioner, proceeded to Gloucester, to take charge of the work and to prepare a report on the whole subject. Mr.

Milner arrived late in August, and remained until the preliminaries were arranged and the first eggs had been taken, when the sickness that has so recently resulted in his death compelled him to leave for the South, in order to avoid the cold and stormy weather of the New England sea-coast. The loss of so enthusiastic and experienced a worker, whose efficient labors have aided greatly in bringing the United States to the front in all subjects relating to fish-culture, was a severe blow to the Gloucester work; had he been permitted to remain, the results would doubtless have been more thoroughly satisfactory.

Owing to the absence of Mr. Milner, the writer has been requested to prepare a report from hurried notes made during the winter. Much of the data has been obtained from personal observations and experiments, either in the hatchery, or at the various fish-wharves, or during visits to the different fishing-grounds in the fishing-schooners of the harbor. Much valuable information has also been obtained from the older and more experienced fishermen and from the files of the local papers. In all cases, however, care has been taken to avoid the acceptance of any statements and opinions without being fully convinced of their correctness, and due allowance has been made for the lack of careful and accurate observations on the part of those interviewed. Many questions requiring much more careful inquiry than we were able to make still remain unsolved, and many points have been wholly omitted in the report for want of sufficient evidence either to disprove or confirm them.

The report, then, especially in the portions relating to the natural history and artificial propagation, must be considered as merely paving the way for a more careful and extended study of the subject.

B.—THE SHORE FISHERIES.

1.—ORIGIN OF THE COD FISHERIES OF CAPE ANN.

Of the many different fisheries in the United States yielding remunerative employment to large numbers of men, the cod-fisheries of New England are the most important and extensive. Dating back as they do even beyond the earliest permanent settlement of the country, and being to the struggling colonists often the only unfailing source of supply, they were at this time of vital importance to the people. In fact, the presence of these fish in the waters of New England had much to do with hastening the settlement of the country, and it was doubtless the knowledge of their abundance that led the merchants of the Old World to send their first vessels to our shores.

The following facts, gathered largely from Babson's History of Gloucester and the files of the Cape Ann Advertiser, give briefly the origin of the Cape Ann fisheries and a glance at their condition at intervals to the present time. Apparently the first that was known of the presence of the codfish in this locality was in 1602, when Bartholomew Gosnold, in the ship Concord, while on a voyage of discovery to Amer-

ica, reached the coast of Maine, and sailing southward passed "the mighty headland, which, on account of the great numbers of cod-fish with which the voyagers 'pestered their ships there', then received the name of Cape Cod." From this date foreign merchants, principally those of England, fitted out fishing-vessels for America, these visiting points on the coast of Maine, and meeting with varying success. In 1622 these parties, having found the expenses of the enterprise greater than the catch of fish would warrant, began to devise methods of lessening them. They soon decided upon a plan whereby the vessels should take out a number of men in addition to their regular crews, these to assist in taking the fish, and to be landed on the shore after the trips were secured, where they were to remain during the rest of the year to clear the soil and engage in agricultural pursuits, living chiefly on the natural products of the land; and to devote their time during the fishing season to loading the vessels that were to be sent yearly to the little colony. Accordingly, in 1623, a ship left Dorchester, England, and proceeded to the usual fishing-grounds, coming later into Massachusetts Bay, where she secured the balance of her trip, and, after leaving fourteen men at Cape Ann with suitable provisions, sailed for Europe. The same year a patent of the land was granted to the New Plymouth colony, who in 1624 built a fishing-stage at Cape Ann, the Dorchester fishermen arranging to share the patent with them. The following year a man was sent from Plymouth to build salt-pans at this place, but, the fisheries proving unremunerative, were abandoned by both parties, and the colony was broken up, a part of the Dorchester men returning to England while the remainder removed to Salem.

The next fishing interests at Cape Ann were in 1639, when the general court passed an act for the encouragement of Mr. Maurice Thomson and others, providing for the establishment of a fishery plantation, and granting certain exemptions to fishery establishments, in order to encourage the colonists to engage more extensively in the capture of the different species. This seemed to have a beneficial influence on the fishing interests of the section, and they gradually grew into a more flourishing condition. But it was not until the beginning of the last century that these fisheries assumed important proportions, and then, for the first time, ship-building was extensively carried on, and Cape Ann sent a large fleet to Cape Sable and Sable Island for cod-fish. In 1741 Gloucester owned about 70 sail, and at the beginning of the Revolutionary War she had 80 sail engaged largely in the bank-fisheries, with nearly twice as many chebacco boats fishing along the shore. The effect of the war, together with the small catch of the vessels, resulted disastrously to the fishing interests, and at the beginning of the present century the fleet had dwindled down to 8 sail of more than 30 tons. But while the bank or offshore fleet had been so reduced the smaller crafts had continued to increase, and there were at this time fully 200 chebacco boats, aggregating about 3,000 tons, fishing on the inshore grounds.

In 1819 the fisheries were in such a state of depression that Congress passed "the bounty act" for their encouragement. This seemed to put new life into the business, and in 1825 over 150 sail fitted out for the different banks, and by 1847 the fleet had been increased to 287 sail, with an aggregate of 12,354 tons, or an average of 43 tons, carpenters' measurement, to the vessel. The Cape Ann fishermen first visited the famous George's Bank fishing-grounds about 1830, and by 1850 this locality had become a favorite resort for both the cod and halibut fleets.

In the spring of 1879 there were 39 fishing-firms at Gloucester, and 378 fishing-vessels of over 5 tons burden sailing from the harbor. Of this fleet 174 sail visited the distant banks for cod, 44 engaged exclusively in the halibut fisheries, 66 were provided with purse-seines for catching mackerel, 8 fished for both cod and halibut, 78 fished along the shore for cod, pollock, haddock, hake, and cusk, and the remaining 8 sailed about in search of squid to supply the bank cod-fishermen with bait. Of the 174 offshore cod-fishermen, 130 went to George's and Brown's Banks, and the remainder to La Have, Quereau, Western and Grand Banks. In addition to the above the other towns of the vicinity had each small fleets engaged in some branch of the fisheries; so that the total number of fishing-vessels belonging to Cape Ann at this time reached upward of 415 sail.

Thus the fisheries of Cape Ann have been continuously prosecuted for two hundred and forty years. Small at first, they have met with varying success, reaching their lowest ebb about the year 1800, since which time they have gradually grown in importance, until to-day Cape Ann is the center of the marine fisheries of America; and Gloucester, which from its excellent natural advantages early became prominent, has continually strengthened itself, until it has come to be the great fishery metropolis of the country; and is now, by the aid of laws and business customs, which tend to transfer the business from the fishermen to the capitalists and from the smaller to the larger dealers, gradually absorbing the fishing interests of the State.

With this large fleet engaged in the various branches of the fisheries, and visiting so many different localities, the quantity of fish landed in Gloucester is enormous; the cod-fish alone for the year ending June 30, 1879, reaching 36,665,620 pounds of cured fish, which, at the low average of three cents per pound, would have a total value of about $1,100,000, This quantity of cured fish represents not far from 91,650,000 pounds of round fish, or, on the supposition that the fish average 15 pounds each, over 6,100,000 cod in number. These figures, though not absolutely correct, probably vary but little either way from the actual number landed in Gloucester during the year mentioned. The data from which the calculations have been made were taken partly from the weekly reports of the Cape Ann Advertiser and partly from notes made during my stay in Gloucester.

In looking over the history of the fisheries, we find that when the bank-fisheries have prospered the shore-fisheries have been neglected, but when for any reason the bank-fisheries have been unprofitable the fishermen have resorted to their boats and small vessels for a livelihood. Thus, in 1804, when the bank fleet had been reduced to 8 sail, the shore crafts numbered nearly 200; but when in 1847 the off shore vessels had increased to 287, the chebacco boats numbered scarcely 35, these fishing during a portion of the season only.

We are told that the chebacco boat originated with the fishermen of Cape Ann, and that it derived its name from a river on the north side of the cape, where it was first extensively built. These boats were usually of about 15 tons burden, rigged with two masts but no bowsprit, and had a small forecastle or "cuddy" forward, affording sleeping and cooking accommodations for the four or five men that constituted the crew. The fishermen often ventured fifteen to thirty miles from harbor in them, remaining four or five days before returning to land their catch.

The first small boats extensively used were known as the Hampton boats, from the village where they were first built. These are still used by many of the shore-fishermen of Maine and Massachusetts. They are open lap-streak boats varying from 12 to 20 feet in length, propelled either by oars or by means of two sprit-sails; the masts being movable so that they can be placed in the bottom of the boat when not in use.

The common fishing-dory, now so extensively employed, was little used for fishing purposes prior to 1825. It seems to have had its origin with the boat-builders of Salisbury, Mass., about 1775, being long used as a river-boat, and for lightering purposes, before its seaworthiness became known. It is a flat-bottom, lap-streak boat, with sharp, projecting bow, V shaped projecting stern, and flaring sides, having an average length of 13 to 15 feet on the water-line. Occasionally it is propelled by means of a small sail, but oars are more frequently used by the shore-fishermen.

As early as 1828, a few "pinkies," and "square-stern" vessels of 30 to 60 tons burden engaged occasionally in the shore-fisheries, but it was not until 1843, when the halibut-fisheries began to require this class of vessels, that any extensive winter fishing was carried on. These vessels, after finishing their season's work in the halibut fisheries, began to fish along the shore during the pleasant weather, and it was in this way that the winter shore-fisheries originated. This class of vessels rapidly increased in number, and by 1855 had nearly supplanted the smaller chebacco-boats, though it was not till 1870, or later, that the shore-fisheries began to assume their present important proportions. In the spring of 1879 fully 100 vessels ranging from 10 to 60 tons, with 90 additional dories, engaged in these fisheries, and the fleet landed during the year ending June 30, about 14,475,000 pounds of round cod-fish, besides a great quantity of haddock, pollock, and hake.

fisheries are soon at their height. The vessels are usually provided with dories, taking from three to twelve each according to the size of their crews. Such fishermen as are unable to ship on the vessels now row or sail out in boats. These often endure great hardships, as the wind may rise suddenly and drive them out to sea giving them a hard pull of hours before they can regain the shore, while an occasional unfortunate fails to return.

The pasture-school is composed of fish averaging probably between 12 and 14 pounds, some being much larger while others are quite small. In the falls of 1877 and 1878 the fishing was unusually good until the first of January, the average daily catch per man often reaching 800 to 900 pounds, while an active fisherman at times caught nearly twice that quantity.

At the present time there are but few towns on the north side of the cape extensively engaged in the shore-fisheries, and for this reason little is definitely known about the first appearance of the Ipswich Bay school of cod-fish in that locality. We cannot even feel certain of the month when they reach the grounds, as the fishermen have many and conflicting opinions on the subject. From the best obtainable information it seems probable that cod have visited these waters regularly for many years, and that they were formerly taken in considerable numbers by the boat-fishermen of the section who rowed out from the shore in pleasant weather during the winter months. But for a number of years these grounds were nearly deserted, and it was not until 1877–'78 that the shore-fishermen of Gloucester and Swampscott learned their value.

In January, 1879, after the fish had left "the pasture" several vessels sailed for Ipswich Bay, where they found the cod remarkably plenty, returning in a short time with unusually large fares. The news spread rapidly and soon all the shore fleet were in the bay, while vessels of 60 to 70 tons abandoned the other fisheries and fitted out for this locality. Vessels from other towns along the shore soon joined the fleet, and by the middle of February 104 sail, with upwards of 600 men, were fishing within a radius of five or six miles, and 20,000 to 25,000 pounds of round fish were sometimes taken in a day by the crew of a single schooner.

The above number of vessels was reached only during the height of the season, and several causes operated to reduce the fleet so that at times it was quite small. But allowing an average of 45 sail during the entire four months, each vessel carrying six dories, the trawls averaging 800 hooks each, and we have the enormous number of 216,000 baited hooks spread out upon the sandy bottom to tempt the spawning-fish. It is not surprising, therefore, that the catch reached fully 11,250,000 pounds on this little patch of ground between the first of February and the last of May.

Fishermen are agreed that the individuals composing this school averaged larger than those of any school that had previously visited the shore. There were almost no small ones among them, the great bulk

this seemingly accidental variation, that gives every gradation to either extreme, there is a more constant difference in both form and color, due perhaps to the peculiar habits and surroundings of the individual. This difference is so noticeable that the fishermen can easily distinguish the one from the other, and they have come to call the one a school-fish in distinction from the other, which they call a shore-fish or "ground-tender."

The school-fish are supposed to be constantly on the move, remaining usually in the deep water, where they are very active in the pursuit of their prey, consuming such quantities as to keep them in excellent flesh. Such fish are usually very shapely, with small and very distinct dark spots on a light background, and seem to have the head quite small in proportion to the body. On the whole, they are just such fish as would be expected from continued activity and good living. On the other hand, the shore-fish, or "ground-tenders," live constantly among the rocks and sea-weeds along the shore, where the water is less pure and the food less abundant. They seem to lead solitary lives during a greater part of the year, being scattered along different portions of the coast, living upon the little rocky spots, where they feed upon such animals as they chance to find; or at times entering the shoaler water among the sea-weeds, where they feed upon the mollusks and articulates that are often so abundant in such localities. They are generally in poorer flesh than the school-fish, having a relatively larger head in proportion to their bulk, with larger and less distinct spots on a darker background. In addition to these large fish, that for some reason seem to prefer the shore as a feeding-ground, there are many young and immature that have not yet joined the school-fish in their migrations. These fish are the sole dependence of the boat-fishermen in summer, or from June to November, and one must know the grounds pretty thoroughly, and row about from one feeding spot to another, in order to secure any considerable number of them. During the months of June, July, and August, the fishing is quite limited, being confined to a few boat-fishermen who row or sail out daily with hand-lines, returning in the afternoon with from 150 to 300 pounds, which they usually sell at fair prices to supply the fresh-fish trade.

Early in the fall the spawning instincts of the fish cause them to gradually gather from the different parts of the shore to special rocky grounds, where they remain until they have deposited their eggs. At such times, being more numerous in these localities, the fishing becomes more profitable, so that many small vessels and a larger number of boats frequent these grounds, and by the middle of October the daily catch reaches about 400 pounds per man.

Thus far the catch has been composed almost wholly of the young and shore fish; but about the 1st of November the fall school of spawning-fish, known as the "pasture-school," makes its appearance. All the smaller vessels and boats are now pressed into service, and the winter

2.—CHARACTER OF THE FISHING-GROUNDS.

Cape Ann is a prominent headland, dividing the waters of Ipswich Bay on the north from those of Massachusetts Bay on the south. Next to Maine, it has the most bold and rocky shores on the coast of New England, and its rugged granite walls rising to a considerable height above the water, present an inhospitable appearance to the approaching mariner. This granite ridge, of which the Cape is a part, extends some distance from the shore, forming an irregular ocean-bed; and continuing southward, is broken up into a large number of small rocky islands and sunken ledges, separated by deeper channels.

Among these islands and ledges the shore cod, and other species, find a favorite feeding-ground, and the school-fish, though seldom venturing among the innermost islands, come yearly in great numbers to the larger outer ridges where they remain during several months for the purpose of spawning. It is here that the shore-fishermen of Cape Ann find their best fishing during the fall and early winter; the fish being known as the "pasture-school," from the grounds where they are most frequently taken.

Farther east, at a distance of 15 to 20 miles from the shore, and separated from the foregoing by a wide channel of clay and mud, is a ridge of ground about 20 miles long, known as Stellwagen or Middle Bank. This bank lies at the entrance to Massachusetts Bay, between Cape Ann and Cape Cod, with an average depth of 15 to 18 fathoms. The fishermen often resort to this locality when the fish are approaching or leaving the coast, and frequently find good fishing for several weeks.

To the north of the cape is Ipswich Bay, with its low sandy beach and level bottom sinking very gradually until a depth of 25 to 30 fathoms is reached at a distance of several miles from land. The floor of this bay is a vast sandy waste, with only here and there a patch of clay or rocks, the whole supporting but a small amount of animal life, and this limited to a few species. It is essentially a spawning rather than a feeding ground of the cod, and large schools visit the bay for this purpose during the winter, remaining as late as June. The fishermen are just beginning to learn the value of this ground, and in the spring of 1879 over 11,000,000 pounds of round fish were taken, mostly by the Cape Ann fleet.

Farther to the eastward, and extending some distance in a northerly direction, is Jeffry's Bank. This ground is frequently visited by the shore-vessels during certain seasons of the year, and good fares are often secured. It seems more of a feeding-ground for the fish than Stellwagen Bank, and the fishing often lasts during a longer period.

3.—DIFFERENT SCHOOLS.

In examining the cod-fish landed from time to time, one cannot but notice the great individual variation in the species. But in addition to

being of uniformly large size with a few very large. Of over 5,000, selected without regard to size at different times during the season, the average weight was 20¾ pounds.

Fishing continued good in Ipswich Bay until the first of June when the school left the shore, being perhaps hurried in their movements by a large school of dog-fish (*Squalus americanus*) that made their appearance in the bay about this time.

After the school-fish leave the shore in summer the fishermen frequently resort to the outer grounds, such as Jeffry's and Stellwagen Banks, when they often secure good fares from what they suppose to be a new school that visit these grounds for the purpose of feeding. We have had little opportunity for examining these fish, but there seems a strong probability that they belong to the school that have just left the shore, and that they remain on these grounds for a few days or weeks on their way to deeper water.

4.—METHODS OF CAPTURE.

Two methods only are extensively used by the cod-fishermen of Cape Ann. Hand-lines have been used from the earliest times, and are still exclusively employed on the rocky ledges during the stay of the "pasture-school" in the fall and early winter. A visit to the harbor at midnight in November, when the fall fishing is at its height, cannot but impress one with the loneliness of the scene, for all is quiet and the region seems thoroughly deserted. But two hours later the rumbling of wheels and the shrill cry of the baitman cause a great and sudden change, for if the fisherman is behind time he frequently finds that all of the "sperling" have been sold. With the first cry of the baitman, lights may be seen in the hands of the fishermen as they emerge from the cabins of the different schooners, and soon the dull thud of oars is heard and boats approach from various quarters, while men and boys come straggling down the different lanes and by-paths from their homes on shore. The night of the fisherman is over. He secures his bait and returns to his vessel, where the other members of the crew are just beginning the work of the day. Soon the measured stroke of the windlass and the hoisting of sails are heard and the fleet is "under way."

If it is calm in the harbor, as it often is at this early hour, one or two boats are "hoisted out," and with lines fastened to the vessel's bow they tow her toward the outer harbor, where her sails catch the breeze and she is off for the fishing-grounds. The boats are now "paid astern," and the rowers join the other members of the crew, who have assembled in the forecastle to eat their morning meal from their private lunch-baskets, all going to the common reservoir for their mug of hot coffee that has been prepared by the schooner's cook. Breakfast over, each gathers his gear in convenient shape, and after filling his bucket with bait, lounges about waiting for the day. The vessel aims to reach the ground just before light, and at the first sight of his land-marks or cross-bearings the

captain brings his vessel upon some little spot of ground known to be a favorite resort of the cod. Each crew strives to be first on the ground, which is a small rocky ridge five or six miles east-southeast of Eastern Point, with an average depth of 25 to 30 fathoms. After the anchor has been dropped the jib and foresail are "taken in" and the dories are lowered from the vessel's deck. Soon the men, following each other in rapid succession, are off for their favorite spots, the captain and cook, or at times only the latter, remaining to care for the vessel and fish over the rail. It is indeed a lively scene, with 150 dories and upwards of 40 larger crafts, each striving for the best berth on a little ridge of ground not over 50 by 90 rods in extent.

When the desired knob has been reached, the killick is dropped, and the fisherman seats himself upon the middle thwart with his face toward the stern, his lines and gaff by his side, and his bucket of bait before him. A fisherman uses two lines, each having two hooks, the leads varying in weight from three to five pounds, according to the depth of water and the strength of the tide. The hooks are now baited, from three to six sperling being strung on each, and a line is thrown over on either side, being allowed to run out until the lead reaches the bottom when it is "seized up" five or six feet, so that the lower hook just clears the rocks, with the upper one a foot or two above. The lines are now fastened to the inner braces of the boat, and with one in either hand the fisherman sits expectant, slowly moving his arms back and forth in his endeavor to induce the fish to bite. On hooking a fish, he generally stands in the boat, facing the line, which he proceeds to haul quite rapidly until the fish is at the surface, when with one hand he holds the line, and with the other reaches for his gaff to lift the fish into the boat.

The best fishing usually occurs in the early morning, though the hour may vary and even come in the afternoon; but by one or two o'clock the flag is set in the rigging of the vessel as a signal for the boats to return, and as they come alongside, the fish are pitched into the common pile on deck, after which they are "hoisted in," and the vessel starts for home in order to market her catch before dark.

The quantity of fish taken daily varies greatly, being dependent upon the dexterity of the fisherman, the abundance of fish, and the quality and kind of bait used. The largest hand-line catch in a day, as far as we can learn, was secured off Pigeon Cove in the winter of 1877–'78, when a fisherman landed 2,200 pounds of round fish. About the same time two men, fishing from one boat in the same locality, landed 3,900 pounds; while two other boats with similar crews fell only 100 pounds behind them.*

The method of trawling originated with the fishermen of this region, probably with those of Marblehead, about twenty-five years ago, and has since come into general favor. This method is used almost exclusively when fishing where the bottom is smooth; though it cannot be

*Cape Ann Advertiser.

employed on very rough ground, as the trawl becomes fastened among the rocks, and is often lost together with all the fish that are on it. The trawl consists of a long rope to which are fastened, at intervals of four to seven feet, smaller lines called "gangings," each bearing a baited hook at its free extremity. These gangings are from two to four feet in length, and number from four or five hundred to even fifteen or sixteen hundred, according to the length of the ground-line. The trawl has an anchor, weighing from 8 to 16 pounds, at either end to hold it in position, while buoys, connected with these by means of small ropes, float at the surface to mark their exact location. When using trawls the vessel usually carries a dory for each member of the crew save the captain and cook. On reaching the grounds these boats are "paid astern," and as the vessel sails at right angles to the wind, they are dropped in regular order, each being separated from the other by 30 to 60 rods. Each man now takes his position in the stern of his boat, and, after throwing out the buoy and line and lowering the anchor to the bottom, slowly pays out the trawl as the wind and tide carry him along. When all the trawl is out the second anchor, with another buoy and line, is dropped, and the man is picked up by the vessel. In case neither wind nor tide carry the boat along with sufficient rapidity, the fisherman sculls with one hand while with the other he pays out the trawl; or, where two go in the same boat, one usually rows so that the trawl may be set in any direction regardless of the winds or tides. Thus we have lines often a mile in length stretched out upon the ocean's bottom, with hooks at regular intervals of five or six feet, and the cod cannot pass without being tempted to take the bait. The trawls are sometimes left in the water only a few hours, but more frequently they remain over night, and are often taken up well filled with fish. In hauling, the fisherman first rows to his buoy, and pulls up the anchor with one end of the trawl attached. He then takes his position in the bow of the dory with a trawl-tub before him, into which he coils the trawl as it comes from the water, using his gaff to take the market fish into the boat, and "cutting away" all large but worthless fish, such as sharks and skates.

Another method of fishing with the trawl, known as "underrunning," requires a second buoy-line attached to a small weight on the end of the trawl, the other line being fastened to the larger anchor only. By means of this second line the trawl is brought to the surface, while the anchor remains on the bottom to mark its original position. In underrunning, the man stands, as before, in the bow of the dory with a bucket of bait in place of the trawl-tub, merely passing the trawl over the bow of the boat and again into the water on the opposite side, saving such fish as are found and re-bating any hooks that may require it. This method is often employed for two reasons: first, because it retains for a man his old "berth" where fish may be plenty; and, second, from the fact that in this way the hooks are kept almost constantly in the water, so that no opportunities for fishing are lost.

When trawlers are numerous and there is a disposition to dishonesty or "mooning," as the fishermen style it, which consists in taking the fish from the trawls belonging to another vessel under the cover of darkness, each vessel usually anchors near her own trawls in the evening; but ordinarily, when near home, or during stormy weather, the vessels seek shelter in the harbor for the night, starting out in time to reach their grounds at early dawn. Great quantities of fish are often taken on a single trawl, and when a dory has been filled she hoists her signal, and a boat is sent out from the vessel to lighten her. The largest catch by any shore-vessel during the winter of 1878–'79 was made by the schooner George A. Upton, of Gloucester, from Ipswich Bay. This vessel landed an equivalent of 55,906 pounds of round fish as the result of two and one-half days' fishing with eight dories, the trawls averaging 900 hooks each, selling her trip for $569.56.

The method of catching cod with gill-nets, though so successfully used by the fishermen of Norway, has never been adopted by the fishermen of our coast. Knowing of the profits derived from the use of their nets by these foreign fishermen, Professor Baird, who is ever anxious to introduce among the Americans any methods that will result to their advantage in the prosecution of the fisheries, decided to make experiments with them at Cape Ann, with a view to their introduction among our shore cod-fishermen. Accordingly he secured from parties in Norway a set of these nets and forwarded them to Gloucester, to be thoroughly tested by the employés of the Commission at that place. They reached the hatchery when the pasture-school was on the shore, and were set on the favorite fishing-grounds a number of times. But the strength of the twine had probably been affected in transit, and the nets proved far too frail. The strong tide and rough water caused them to catch among the rocks, where they were badly damaged; while numerous holes indicated clearly that large fish had torn their way through the nets, only such being retained as had become completely rolled up in the twine. The nets were always taken from the water in bad order; but the capture of 800 pounds on one occasion, even under these circumstances, seemed to indicate that nets of sufficient strength might be used to good advantage, at least on the smooth fishing-grounds along the coast.

5.—THE BAIT QUESTION.

With so large a fleet engaged wholly in hand-lining and trawling, the question of obtaining and preserving bait is of the utmost importance to the fisherman, and on its abundance or scarcity depends largely the success or failure of his season's work. Cod-fish, though having the habit of snapping at, and at times swallowing, anything that may come in their way, are on the whole quite dainty fish, and when one expects to be successful in catching them for profit, he must have not only a good quality of bait, but also a kind that the fish are known to prefer. So peculiar are the fish in this particular, that the fishermen have differ-

ent names for the various schools, derived from the kind of bait on which they live during the fishing season. We often hear them speak of the clam-school, the herring-school, and the squid-school; and when securing bait they will at times pay exorbitant prices for that kind on which the fish are known to be feeding, rather than take an equally good quality of another kind at much lower rates. Thus, when the fish are feeding on squid (*Ommastrephes illecebrosa*) the fishermen secure squid if possible; the same is also true of the herring (*Clupea harengus*), the capelin (*Mallotus villosus*), and other species. But while it is undoubtedly true that during the feeding season the fish take the hook more readily when baited with that particular species that they chance to be pursuing, and while they always prefer fresh to salt bait, yet we think the fishermen in error when they apply the rule with the same fixedness to the schools of spawning fish, and that the shore-fishermen often lose both time and money by so doing. It is quite interesting to watch the effect of this idea upon the shore-fishermen; for they seem fully convinced that, when one kind of bait has been successfully used, it is utter folly to attempt the use of any other kind. Thus in the winter of 1878–'79, when sperling (young herring) became scarce, the fleet waited fully two weeks, hoping that more might be obtained before they would supply themselves with either frozen herring or clams.

In the winter of 1877–'78 the first vessels resorting to Ipswich Bay for cod chanced to be fishing with clams, and, as a result, clams were used by nearly the entire fleet, though frozen herring could be more easily obtained, and were cheaper. Again, in the winter of 1878–'79, the first vessels resorting to the above locality used frozen herring, and the results obtained were entirely satisfactory. Frozen herring were at once announced as *the* bait, and fishermen provided themselves with these only. A few, however, acting on the experience of the previous season, had contracted for clams in advance, and were obliged to use them. These unfortunates, for such they felt themselves to be, frequently received expressions of sympathy from the other fishermen, and it was the general belief that their catch was much smaller than it would otherwise have been. A comparison of the quantity of fish landed by one of these vessels with that of a vessel of equal size using frozen herring, showed that the bait had little effect on the catch, the trips averaging about the same in size, sometimes favoring the one and again the other vessel. Later in the season, when frozen herring could not be obtained, the vessels went south for fresh herring and alewives (*Pomolobus vernalis* and *P. æstivalis*), and it was not uncommon for them at times to refuse the herring, and to spend several weeks in search of alewives, or again to refuse the alewives and search for herring.

The principal kinds of bait used in the cod-fisheries are clams (*Mya arenaria*), sperling or young herring, fresh and frozen herring (*Clupea harengus*), fresh and salt squid (*Ommastrephes illecebrosa*), fresh and salt menhaden (*Brevoortia tyrannus*), capelin (*Mallotus villosus*), and alewives

(*Pomolobus vernalis* and *P. æstivalis*). The shore-fishermen of Cape Ann use principally clams, frozen and fresh herring (including sperling), and alewives.

Clams are used principally during the summer months and at other times when bait is scarce. They occur in considerable numbers in most of the muddy flats along the shore between tide-marks, being small and scattering near the line of high-water, but gradually increasing in both size and number as the low-water line is neared. To these flats the fishermen resort with their clam-forks and baskets during the hours of low-water. When they are plenty, an energetic worker can dig from seven to nine bushels at a single tide, these making nearly two-thirds of a barrel of bait; but in the vicinity of Gloucester the flats have been dug over so frequently that clams are becoming scarce, and the fishermen are often obliged to buy their supply from other places, at an average price of four or five dollars a barrel.

The sperling, now so extensively used by the shore-line fishermen, average from five to six inches in length. They make their appearance in these waters about the middle of September, remaining until driven off by the coldness of the water late in December. We are told that they were first used for bait by the Swampscott fishermen about 1840, and that the demand did not become general until 1866. The supply now comes wholly from Ipswich Bay, where for the past two years the fish have been unusually abundant. They are taken wholly at night, within a short distance of the shore, by means of dip-nets. The men visit the grounds in 20-foot dories, made expressly for the purpose, and as soon as it becomes dark a torch is placed in the bow, and two men row the boat rapidly through the water, while the third stands ready to secure the fish as they are attracted by the light and gather in little bunches, keeping just in front of the boat. A good dipper will often catch half a bucket of them at a single dip. It usually takes but a short time to secure all that can be sold, when the boat returns to the shore, where a wagon is in readiness to carry the fish to market. Ninety men were engaged in this work during the winter of 1878–'79, landing and marketing about 7,000 barrels of sperling, at an average price of $3 per barrel. During the season six men landed nearly a thousand barrels, while a single crew of three men caught 20 barrels in one night.

The fishermen buy only enough bait to last them through the day, getting a fresh supply each morning, as the fish soon become soft, and when in this condition will not stay on the hook. For this reason they are not suitable bait for the trawl, and cannot be used in the offshore fisheries.

Frozen herring usually make their appearance in the Cape Ann markets about the middle or last of December, from which time they are extensively used as bait by all of the fishermen until April, when the weather becomes so warm that they cannot be obtained. The supply comes largely from the coasts of Nova Scotia and Newfoundland, where

the fish are abundant during the greater part of the winter. Many of the larger Cape Ann vessels engage in the frozen-herring trade during these months, visiting those points where the herring chance to be most abundant, and bringing large trips to the principal New England markets. Formerly they supplied themselves with nets for catching their own fish, and took full crews of fishermen to assist in the work, but of late they often find it cheaper to buy the fish of the natives, in which case they carry only enough men to work the vessel on the passage. The herring are first frozen on the shore, after which they are thrown, with a little straw, into the hold, and at times even the cabin of the vessel is filled, the crew living in the forecastle. A vessel thus loaded carries from three to four hundred thousand fish. If the trip is to be sold to the fishermen, the vessel is anchored in the middle of the harbor, and a flag set in the rigging as a signal that bait may be obtained. The fishing-vessels are brought alongside of the "baiter" and the herring are counted out, and quickly transferred by the crews to beds of straw or canvas, where they remain in good condition until such time as they are needed. The price varies from 25 cents to $1 per hundred, the average being a trifle under 50 cents. The fish have an average length of nearly 12 inches. In preparing them for bait, they are first slivered, and the head and tail thrown away, after which the balance is cut so as to make about six baits. A vessel carrying eight dories and fishing with trawls requires from eight to twelve hundred herring for a day's fishing.

After the season for frozen herring is over, the fishermen often find great difficulty in securing bait of any kind. In the spring of 1879 shore-fishing was almost wholly suspended for several weeks on this account. About the 1st of May a small school of herring made their appearance in the locality, and the water was soon filled with nets for their capture, but the supply was so small as to afford relief to only a few of the smaller boats. Later mackerel were purchased from the market-fleet when they were cheap, but the price was generally so high that the fishermen could not afford to use them. Again, from the 10th of May until the 1st of June almost no bait could be found in the locality, and the shore-fishing by the small boats was practically suspended. The larger vessels started out to seek it elsewhere, and were often obliged to go as far as Greenport, Long Island, before a supply could be obtained. In this way two weeks were often spent in getting enough for three or four days' fishing. The offshore fleets were also seriously hindered in their work by the scarcity of bait, and usually spent much more time in search of it than they did on the fishing-grounds.

While the season of 1879 has been an exceptional one, owing to the absence of the menhaden (*Brevoortia tyrannus*) from the Gulf of Maine, yet the question of the bait supply has for years been growing more serious, and the difficulty of obtaining it has been constantly increasing. The expense has also been proportionately increased, until it now seriously reduces the profits of the business.

Professor Baird on learning of this difficulty began a series of experiments to throw light on the subject. For this purpose he caused a refrigerator, with a capacity of fully a ton, to be placed in the laboratory of the United States Fish Commission at Provincetown, Mass., where by the use of salt and ice he easily obtained a temperature of 18° F., and found no difficulty in keeping fish for any desirable period. He now suggests a way out of the bait difficulty by the building of large refrigerators in the principal fishing-towns along the coast; these to be filled when bait is plenty and cheap, and the supply to be kept until such time as it may become scarce. He also suggests the use of small refrigerators in the holds of the fishing-vessels, and thinks that by this means bait can be kept as long as desired and as cheaply as by the present method.

The time has undoubtedly come when this question should receive the serious attention of the fishery capitalists of New England, and it only remains for some one actually engaged in the fisheries, or for some enterprising capitalist, to act upon these suggestions in order to bring the plan into general favor.

6.—DISPOSITION MADE OF THE FISH.

The two principal markets for the shore fishermen of Cape Ann are Boston and Gloucester. The former uses the bulk of the fresh haddock, while the latter buys most of the cod, hake, pollock, and cusk.

In former years it was the custom in all of the fishing-towns along the coast for the fishermen to cure their own catch or to land the fish at the wharf of some shoresman who would "make" them at his leisure, charging from 6 to 8½ per cent. of their value for his labor. In either case the fish would not be sold till late in the fall, and it was often nearly spring before the fisherman received any money for his season's work. Being usually a man of small means he had no money to carry himself and family through the season, and he was obliged to arrange with the merchant to supply him with goods until the fish could be caught, cured, and sold. In this way the merchant's bills came to have a value largely dependent upon the abundance and price of fish, and, if the season was a poor one, the accounts were often worthless. To protect himself against such losses the merchant came to charge exorbitant prices for his goods, and mutual dissatisfaction was the result.

Many of the towns still do business in this way, but a few have adopted the cash system. Gloucester was among the first to adopt this method, and in this way drew a large number of fishermen into the town, and greatly increased the size of her fleet. The Cape Ann cod-fishermen now receive their money as soon as the fish are landed and weighed, and thus many of the evils of the credit system are overcome.

In addition to this, there is usually so much competition that a fisherman can secure good prices for his catch, and can sell in any way that he thinks most profitable. Early in the fall, when fish are scarce, he usually sells his fish round, but later in the season he often finds it to

his advantage to "gut" or even split them before selling. The average price paid for cod during the winter of 1878–'79 was $1 per hundred pounds for round, $1.25 for gutted, and $2 for split fish.

The method of dressing is often quite interesting to the stranger, as the work is carried on with great rapidity. A single dressing-gang consists of three men, each performing a particular part of the work. After the fish have been weighed and pitched into a tub—usually half of a hogshead—the "header," armed with a sharp and pointed knife, seizes the fish by the mouth with his left hand, and rests its back upon the edge of the tub. He then, with one stroke of the knife, severs the attachment between the gill-covering and the belly, and inserting it in the opening thus made, slits the abdomen to the vent. He then makes a cut on either side of the head at the base of the skull, and while its back still rests on the edge of the tub, and his left hand holds its head, he places his right hand upon the body of the fish, and throws his weight upon it, separating the backbone from the skull and tearing the head from the body, cutting away any flesh that tends to hold them together. The fish is now allowed to fall back into the tub, when the "gutter" seizes it and removes the viscera, transferring the livers to one barrel at his side, and the ovaries to another, allowing the remainder to drop down at his feet or to fall back into the tub. He then throws it upon a table, where the "splitter" places its back against a little strip of wood to keep it from slipping, and holding the fish open with his left hand, takes a splitting-knife in his right and cuts along the left side of the backbone to the base of the tail. The fish now lies open on the table, when with a hard stroke of the knife he severs the backbone near its middle, and catching the end thus freed, lifts it slowly, and following along its side with his knife quickly cuts it from the body, sliding the fish from the table into a tub of water, where it is washed before going to the salt-house. Three men will usually dress from two to four thousand pounds per hour, the quantity varying with the size of the fish. When a large quantity is to be dressed, or when dressing on board a vessel, a double gang of seven men is usually employed, the extra man, called the idler, pitching the fish into the tubs and drawing the water to wash them after they have been split.

Two methods are employed in curing the fish. By the first they are placed in butts, with a quantity of salt, and covered with the strongest pickle. Here they must remain for about two weeks in order to become thoroughly "struck," after which they may be placed on the flakes, when, after one or two days' drying, they are ready for the market, though still quite damp and full of salt. This method is employed only on shore, and such fish are known as pickle-cured fish, being inferior in quality to the kench-cured fish, though they find a ready market in all the inland towns.

In "kenching," the fish are salted in piles, either in the hold of a vessel or on the floor of a fish-house. Each fish is placed back downward, so

that, as the salt is dissolved by the moisture from the body, the pickle will pass into the flesh and thoroughly preserve it. When properly salted, fish may be kept in kench for fully a year, though they are seldom allowed to remain more than four or five months, as they are liable to grow strong and musty. To prepare these fish for market, they are first thoroughly washed and scrubbed, and then placed on the flakes, where they are allowed to remain until dry.

A new brand of fish, known as the boneless cod, has been introduced within the last few years, and is meeting with a ready sale. By this method pickle-cured fish of different species are taken to the boning-room, where men and boys are employed in stripping off the skin, cutting out the fins and bones, and cutting the flesh into convenient shape for packing in small boxes for the retail trade.

A large number of observations have been made to ascertain the exact loss in weight of different members of the cod family from the time they leave the water until ready for market. From these it is found that the pickle-cured cod loses from 60 to 66 per cent.; the haddock, 62.3; the pollock, 59.8; the hake, 55.5; and the cusk, 50.5. The additional loss of the cod in boning is 21.9 per cent. The details of the above are given in Tables V to XII, inclusive.

In addition to the market-cured fish, that represents the principal value of the cod, other parts of the fish are often saved. Indeed, but little of either the weight or bulk of the fish is thrown away. When considered separately, any one of these parts has a value seemingly insignificant for the individual; but when taken collectively, they have an importance that cannot be neglected in estimating the money value of the cod-fisheries.

The livers, from which both medicinal and tanners' oils are made, are, next to the cured fish, the most valuable. These are always saved by the fishermen, and bring from 8 to 15 cents per gallon, according to the season when the fish are taken. They are in the best condition from July to September, when a thousand pounds of round fish will furnish four or five gallons, yielding from eight to ten quarts of oil, and are poorest from January to May, when only two and three-fourths gallons, yielding but four or five quarts of oil, can be obtained from a like quantity of fish. The livers are usually boiled in large kettles, and the oil thus freed rises to the surface, when it is dipped off and put into barrels for the market. In the bank-fisheries each vessel is provided with butts, where the livers are kept until the oil has been separated by partial decomposition and the natural heat of the sun. This method is known as sun-trying. Much of the oil from the livers of the shore-fish is used for medicinal purposes, and in the crude state brings about 50 cents per gallon, while the sun-tried oil is sold as tanners' oil, at from 26 to 55 cents per gallon.

The ovaries or eggs of the fish come next in importance. During "war times" these brought from $8 to $12 per barrel, and found a ready

sale, even at these prices, for use as bait in the sardine fisheries of France. At that time all the fishermen made a practice of saving them when they could be obtained. Of late, owing to a number of different causes, the price has declined, and during the winter of 1878–'79 the fishermen have received only $1.25 for them in a fresh state, and the price when cured for exportation averaged only $3 per barrel. For this reason most of the offshore fishermen refused to save them, and the quantity landed in Gloucester was a trifle under 1,800 barrels, these being mostly brought in by the shore fishermen. A fair average yield during the winter, or from September to April, is about one barrel to every 4,000 pounds of fish; at other seasons they cannot be obtained.

The sounds or air-bladders of the fish have recently become quite valuable, and are now frequently saved. They are prepared for the market in different ways, depending upon the use for which they are intended. By far the greater part are dried, and sold to factories in the locality, together with sounds of the hake, where they are made into marketable gelatine and used principally in clarifying beer. Some are also put upon the market as cooking gelatine, while others are made into glue. Sounds are also extensively eaten, and are by some considered a great luxury. When put up for this purpose they are pickled and mixed with the tongues of the fish, and in this condition bring from $8 to $12 per barrel.

In the offshore fisheries the sounds usually become the property of the vessel's cook, who cuts them from the bone and prepares them for market during his leisure hours. On shore this work is usually done by men and boys, who cut and scrape them for a certain part—usually one-third to one-half of their value.

From Capt. J. W. Collins, of Gloucester, we have the following facts relating to sounds and the sound trade: One thousand pounds of round cod yield from nine to ten pounds of sounds; these, when scraped, weigh about 6½, and after salting, 5¾ pounds. It requires four pounds of green sounds to make one pound of dried. The price paid during the year 1879 for dried sounds was from 22 to 35 cents, the prices received by the fishermen being as follows:

	Cents.
Grand Bank sounds, pickled, per pound	3½
George's Bank sounds, pickled, per pound	4½
Shore sounds, green, per pound	5

Cod tongues are also saved, and find a ready sale in the retail markets, at from 8 to 15 cents per pound. On the offshore vessels these are often cut from the fish as soon as they are taken from the water, the fishermen keeping account of the number of fish caught in this way, and at night each brings his dish of tongues to the captain, who, after counting and crediting them to the fisherman, empties them into the common pile, when they become a part of the general stock and are sold at from 2 to 5 cents per pound. On shore they are cut out by boys and men, each

person having half of all he gets. An average yield is about five pounds to a thousand pounds of round fish.

Again, the skins, bones and fins, that come from the places where boneless fish are prepared, usually bring when delivered at the factories an average price of $1 to $2 per wagon-load. I am told that these make the finest quality of isinglass.

The above are the only products that have a market value as merchandise, but in addition many poor people resort to the dressing-wharves during the winter season and cut out the cheeks of the fish, the process being known to the fishermen as "scalping." These are considered very fine eating, and many people are in this way supplied with excellent food, who would be compelled to go without in case they had to purchase. That which now remains after all these different parts have been saved is usually thrown into the sea, though at times the farmers cart it away to manure their land.

Thus we see that though small for the individual, when considered collectively these minor products have an enormous value for the cod-fisheries of the country. But barring those which, though useful, have no market value, and considering the marketable ones only, we find that in the shore-fisheries, when all of the above-mentioned parts are saved, they represent a value equal to 14½ per cent. of the total value of the fish as it comes from the water.

C.—NATURAL HISTORY OF THE COD.

1.—GEOGRAPHICAL DISTRIBUTION.

The cod-fish has perhaps a wider range than any other of our important food-fishes. On the east coast of America it is found from the polar regions on the north to Cape Hatteras on the south, occurring in vast numbers in the vicinity of Labrador and Newfoundland and on the noted fishing-banks lying to the south and west. On the west coast a closely-related species occurs, and the cod-fisheries of the Pacific are being rapidly developed. In the Old World the cod has a wide geographical range, and is very abundant in some localities, the cod-fisheries of Norway being among the most extensive in existence.

It is not our purpose, however, to go into any general discussion of the natural history of the cod, but merely to treat of the subject with special reference to the species as found in the waters of Northern Massachusetts, where it occurs in greater or less numbers, from the shore line to a depth of 90 or 100 fathoms, on all of the rocky spots and ledges, during the entire year. It is also frequently found on sand and clay, but seldom, if ever, remains on muddy bottoms. Cod are most plenty in this locality from November to June, when they visit the shore for the purpose of spawning, during which time they usually remain in from 15 to 40 fathoms of water.

2.—CHARACTERISTICS OF THE COD.

Cod-fish are gregarious in their habits, going in schools of greater or less size, and are governed in their movements by the presence or absence of food, the spawning instinct, and the temperature of the water. When migrating, the schools are quite dense, though by no means like schools of menhaden or mackerel. But when they reach the feeding ground they seem to distribute themselves over a large area, though more or less grouped together in little bunches. This is particularly noticeable on the shore, when the fish are moving about in search of food, and the fisherman soon catches up all that chance to be on one patch of rocks, and must then row to another in order to find a new supply. The same thing is seen on western banks, where a vessel usually carries dories to distribute her crew over different parts of the ground, and often, by setting her trawls in one locality for a day or two, seems to catch up all of the fish, and must then "shift her berth." Fishermen also cite many instances where the fishing is excellent on a few, particular, well-defined spots on different parts of the ground, while almost no fish can be taken in other places.

During the spawning season this tendency to become scattered is less noticeable, for the instincts of the fish seem to bring them nearer together, and great numbers are often taken in one particular locality. Even here, however, the tendency to separate into groups occurs, for some boats find good fishing while others, but a few rods away, catch almost nothing; and in trawling, some parts of the line have a fish on nearly every hook, while other parts take only a scattering one.

In schooling, both sexes are always found together, whether it be on the spawning or feeding ground or on the journey; but the relative numbers of each seem to vary greatly, and we have been able to discover no invariable rule whereby one can predict with certainty the sex that will first appear, or that which will be most abundant at any given time during the season. The fishermen have a commonly accepted tradition that in the spawning schools the females always come first and the males later, but this theory is not supported by facts. Observations were frequently made on the relative numbers of the two sexes landed by the shore-fishermen between September, 1878, and July, 1879. The results showed that during the early fall, or before the school-fish had made their appearance, the fish were nearly equally divided between males and females—first the one and then the other being more abundant. When the school-fish first reached the shore early in November the males were a trifle more plenty than the females for about a week, but from that date until they left the grounds the females were taken in greater numbers, sometimes in the proportion of two to one, and at others in nearly equal quantities. In the Ipswich Bay school during the first two or three days in February there were ten males to one female; by the middle of the month the females composed about 40 per cent. of the

catch, and from this date until the 1st of June the males numbered two to one. From reliable fishermen we learned that the same was true of the fish on the offshore banks, and that, though varying greatly in their relative numbers, both males and females were always present.

There is usually a great difference in the size of the individuals taken by the fishermen on the shore feeding-grounds in a single day, for the young and "ground-tenders" remain on these rocky ledges during the entire year, and late in the season the school-fish come in upon the same grounds and are naturally taken with them. But when the school-fish visit a locality not frequented by the young, as they do in Ipswich Bay, there is a noticeable absence of immature fish, and the catch is composed almost wholly of individuals of large size.* Thus, in the winter of 1878–'79 many trips of from twenty-five to forty thousand pounds were landed with scarcely a small fish among them, while vessels fishing only a few miles distant found young fish plenty, and there were occasional instances where such vessels caught only small ones. Again, though the school-fish may differ considerably in size, we have not found one, thought to belong to their number, that had not reached maturity. Indications strongly favor the idea that the young remain separate from the school-fish during the first few years of their lives, and we are led to believe that, though they are often taken together, the occurrence is accidental and the young will not follow the old in their migrations until they reach maturity, though after this point is reached they seem to mingle freely without regard to age.

The cod-fish sometimes make long journeys from one bank to another, and, indeed, from one region to a very distant one. It is, of course, nearly impossible to trace their movements at such times, and one can usually only guess at the place from whence they come or the distance traveled.

During the winter of 1877–'78 an unusually large school visited the coast of the United States. At this time cod were more plenty along the shores of New England than for many years. Among the fish captured at Cape Ann and other points were quite a number with peculiar hooks fastened in their mouths. These hooks gave a clew to the movements of the fish, for they differed from any in use by the American fishermen, and proved identical with those used by French trawl-fishermen on the Grand Banks, and indicated that the fish must at some time have been in that locality, as the hooks probably came from no other place. If the above be granted as proven, the fish must have traveled a distance of five to eight hundred miles at least, and, as a portion of the school continued well to the southward, some individuals must have journeyed much farther. Most of the schools that visit the shore have no such tag or mark whereby their former locality may be learned. They are thought to come directly in from the deep water and to depart by the same route, but where they spend the summer months is not known.

Cod-fish are probably governed in their movements by the abundance and migrations of food, the spawning instinct, and the temperature of the water, though the last named seems to exert but little influence. It is generally acknowledged by the fishermen that during the feeding season fish are plenty only where food exists in considerable quantity, and that after "cleaning up" one part of the bank they go to another. They also follow schools of bait for long distances, living upon them until they are broken up or entirely destroyed. Thus they often follow the capelin (*Mallotus villosus*) into the shoal water, and even drive immense numbers of them upon the shore.

The spawning instinct seems to exert a decided influence upon the movements of the fish, for we find them visiting the same locality year after year during the spawning season, often remaining for several months at a time. The fish that visit the waters of Cape Ann during the winter, doubtless come in for the purpose of spawning rather than for food. This seems clear from the fact that they do not arrive when bait is most plenty, nor do they follow any species to the shore. On the contrary, the pasture-school usually arrives about three weeks after the large herring have left the coast, and remains on the south side of Cape Ann, while sperling are abundant in Ipswich Bay. The Ipswich school is also the largest after the sperling have been driven away by the cold weather, and remains on the sand-flats, which supply almost no food. From these facts we are led to believe that food has little influence upon the movements of the fish during the spawning season.

The instinct that leads the spawning fish to seek the shoal water in such great numbers is certainly a wise one, for they generally select spawning-grounds where the tide runs strong and the water is rough, and the large number of individuals is absolutely necessary, that the water may be filled with germs for their successful impregnation. If, instead of schooling in such numbers during this period, they remained scattered over a large area, almost no eggs would be fertilized.

Again, while food is not essential to the spawning fish, it is of vital importance to the young, and it seems a wise provision that these should be brought into being where food is abundant, rather than that they should be hatched in mid-ocean, where almost no suitable food exists.

Cod-fish live at a depth varying from a few feet to over 100 fathoms. They have occasionally been seen schooling or feeding at the surface on the fishing-banks and on the coast of Labrador. In February, 1879, there was good fishing in three fathoms of water within a few rods of the shore in Ipswich Bay; while in May of the same year large numbers were taken in 110 fathoms from "the channel" near Clark's Bank. They seem to prefer a depth of less than 70, and by far the greater numbers are caught in from 18 to 40 fathoms.

In moving from one bank to another, where the intervening depth is much greater, it seems probable that, instead of following the bottom, they swim in a horizontal plane, following a stratum of nearly uniform

density and temperature. The fishermen of Cape Ann have often caught them with 70 to 80 fathoms of line, between Brown's and George's Banks, where the sounding-line indicated a much greater depth. The finding of pebbles and small stones in their stomachs is not an uncommon occurrence. The fishermen regard these as an unfailing sign that the fish have either just arrived or are about to leave the bank. These stones may play no small part in adjusting the specific gravity of the fish to that of the stratum of water in which they are to move.

There seems to be a tendency for the large fish to remain in deeper water or nearer the bottom than the small, and usually beyond a certain depth; the deeper one fishes the larger the fish. Formerly, in hand-lining from deck on the banks, the vessels often anchored in 80 or even 90 fathoms, and the catch averaged over two-thirds large; but in hand-lining from dories they seldom fish in over 50 and usually less than 35 fathoms, as they find it difficult to handle so much line, and the catch runs about two-thirds small. The same is true in fishing at different depths at the same time and in the same place. Thus, of two men fishing side by side from the deck of a vessel, the one with his hook on the bottom will catch much larger fish than the other who lets his line but part way down. Larger fish are also taken on the trawl than on the hand-line, for the former lies constantly on the bottom, while the latter may be raised to any distance above it.

The size of the species varies greatly with the different individuals. The boat fisherman visiting the rocks and ledges along the shore in summer catches fish weighing from 2 to 60 pounds, the average being a trifle under 9 pounds. The school-fish run larger, those on the south side of the cape, in the fall of 1878, averaging about 12, and those in Ipswich Bay, later in the season, fully 20¾ pounds. Probably the latter were the largest as a school that have ever visited the shore. On George's Bank, where the largest cod-fish are taken, trips are sometimes landed where the average weight would be fully 40 pounds round, but such cases are exceptional. The largest specimen that we have seen was taken by the schooner Northern Eagle, Capt. George H. Martin, in Ipswich Bay, March 10, 1879, and is now in the collections of the National Museum. It measured 5 feet and 2 inches, and weighed 99½ pounds when landed, probably weighing fully 105 pounds when taken from the water.

We have also authentic record of a specimen captured off Cape Cod in February, 1878, that weighed 107 pounds after being eviscerated, which is equivalent to over 125 pounds round. Other instances have been recorded in the local papers in the vicinity of Cape Ann, from time to time, where cod of unusually large size have been taken; and the Cape Ann Advertiser has very recently noted the capture of one weighing 180 pounds by a vessel belonging to Newburyport, Mass. Whether this was the actual weight or an estimate we have not learned.

Of the many specimens weighed and examined during our stay in Gloucester the average weight of the females exceeded that of the males

by nearly 2½ pounds—a difference only partially accounted for by the presence of the eggs. Whether this would be true for other localities or for other years is not known.

The general form of the different individuals varies but slightly, though there is considerable difference in their relative proportions. No external character has been noticed whereby the sexes can be distinguished, and even the most trained observer cannot separate them when green until they have been opened. The difference in the relative proportions is considerable, and the length is not a reliable indication of weight. Some fish are short and thick while others are long and slender. Table No. IV gives the measurements and weights of a number of fish of different sizes, and shows fully the extent of this variation.

The difference in the shape of the shore and school fish seems largely the result of food and habits. The school-fish, moving about in pursuit of food, becomes thick and plump, so that the head appears small in proportion to the body, while the shore-fish, subsisting on such food as can be found on the rocks, grows thin and gaunt, giving its head a larger relative size.

There is a remarkable variation in the color of different individuals of the species. This is doubtless due to surrounding circumstances, or to the character of the bottom on which they live, and to the age of the fish. The young when first hatched are nearly colorless, with the exception of a few dark star-shaped pigment cells, most noticeable in the eyes, and sparingly scattered over the whole surface of the body. These increase rapidly in number during the first few days on certain portions of the body, giving the little fish a very peculiar banded appearance. At the age of six months they are still quite transparent, and the upper parts are well covered with minute black dots, more prominent along either side of the dorsal fins, and gradually shading off into lighter underneath, with the belly nearly white. At this time the fish have a peculiar golden tinge, deepest along the back and sides. Traces of the dark bands still remain, but these are more noticeable on account of the intervening lighter spaces, that seem to extend irregularly downward and backward, giving the fish a blotched or mottled appearance. Gradually the young fish living along the shore come to resemble more nearly the adult in the relative size and distribution of the spots, until at the age of twelve to eighteen months there is a marked similarity between them. But the young continue to live among the rocks and ledges covered with algæ, and soon begin to show a reddish tinge; this increasing and varying with the individual, often giving the fish a deep red color. These red fish are known to the fishermen as rock-cod, from the bottom on which they are taken. They are usually small, having a weight of only a few pounds, but some retain the color until they are of large size, and one specimen was seen during the summer of 1878 weighing 46 pounds. The ordinary shore-fish or ground-tender is quite dark, with the belly of a dirty ash, and the spots usually large and indistinct on a dark back-

ground. The regular school-fish, on the contrary, is very light, with smaller and more distinct spots on a lighter background, and has the belly nearly white. Specimens of cod have also been seen in which the whole upper surface of the body was of a uniform straw or lemon color, gradually shading into lighter underneath. A fine specimen of the above was secured in the summer of 1878, and is now in the National Museum.

3.—FOOD OF THE COD.

A list of the stomach contents of the cod would be of little value, except in throwing light on the food that the fish seem to prefer, by showing the relative quantities of the different kinds. A full list, including everything that has been found in the species, would be very long, and embrace nearly everything, whether organic or inorganic, that chanced to come in its way. Any bright or curious object often attracts its attention, and is very likely to be swallowed by it. Thus knives, nippers, and even vegetables lost or thrown from the vessel are frequently found in the stomachs of the fish when they are being dressed. Stones, too, are not uncommon at times, and over a pound has been taken from a single fish. The list of fishes, articulates, and mollusks seems only limited by the size of the individuals or their ability to escape. But while such a variety of food is found in the cod, its principal food is limited to a few species of fish and a small number of mollusks. Among the former the more important are the herring (*Clupea harengus*), capelin (*Mallotus villosus*), lant (*Ammodytes americanus*), and a few others. It often follows these fish in their migrations, feeding upon and destroying great numbers of them, and at times shows great dexterity in their capture. I am told that in the spring of 1879 an immense school of herring made their appearance on and moved slowly across George's Bank, and that with them came the largest school of cod that has been seen in that locality for a long time. The cod remained constantly among the herring, so that, when the latter had passed the fishing fleet, the vessels were obliged to weigh anchor and follow them in order to secure the cod. The cod also drive the capelin into the shoal water, and even upon the shores of Newfoundland and Labrador, in immense numbers, and, when they have reached the shallow bays, fishermen report the water as fairly white from their splashings in their active and eager pursuit of their prey. Among mollusks, squid (*Ommastrephes illecebrosa*) and the common bank-clams are their principal food, the former being preferred to any other species, and the latter often occurring in such quantities in the stomachs of the fish that the French fishermen on Grand Banks frequently catch a large part of their trip on bait secured in this way.

During the spawning season the cod-fish cease to search for food, and give less attention to feeding than at other times, though they will usually take the bait when placed before them. That they do not search for food is shown by the fact that the pasture-school remained

within a few miles of a large school of sperling without being drawn after them; and that the Ipswich Bay school was largest after the sperling had left the coast, and remained for a number of months on sandy wastes which supported only three species of invertebrates, *Buccinum undatum*, *Fusus* sp., and *Asterias vulgaris*, in any considerable abundance. The examination of the stomachs of several hundred individuals showed four-fifths of all to be entirely empty, while a greater part of the remainder contained only bait picked from the trawls of the fishermen. A small number contained fish of one or more species that had probably been captured in the locality, while a few scattering invertebrates were found. Of the species mentioned as abundant on the grounds, not a star-fish and but two shells of one species and one of the other were found. But it was clearly shown that the fish would not refuse food, for often the stomachs were well filled with bait picked from the trawl before the fish were hooked. From 10 to 15 pieces were frequently found, and in one case 18 were counted.

The females when fully ripe seemed less willing to feed than at other times, and few were caught with the moving hand-lines; but when the trawl was used, thus leaving the bait motionless on the bottom for hours at a time, they were induced to bite, and many were taken with the eggs running from them. Ripe males seemed to bite readily at any time.

The young fish, as has been remarked, seems to spend the first three or four years of its life in shoal water, among the rocks and algæ. Here its food consists at first of the minutest forms, and later principally of small crustacea, though it often picks up mollusks and worms, and even enters the harbors in summer, where it remains about the wharves, picking up bits of refuse thrown from the fish-houses. The young fish were so plenty in Gloucester Harbor during the summer of 1879 that boys often caught 25 or 30 of them in an hour with hook and line.

4.—ENEMIES OF THE COD.

The cod-fish seems to have few enemies. Among fishes its principal enemy is the dog-fish (*Squalus acanthias*). These fish make their appearance in large schools on the shores of Northern Massachusetts early in May, where they remain until September, moving about from one locality to another, and driving everything before them. They are probably the most pugnacious of any species in the waters of New England, and cod, as well as other fish, are often brought to market bearing marks of their sharp teeth and horny spines. The arrival of a school of dog fish in any locality is the signal for all other species to leave; and in this way the work of the fisherman is often suddenly terminated.

Halibut (*Hippoglossus vulgaris*) are also regarded by the fishermen as enemies of the cod, and many cases are cited where, in former years, they drove them from the fishing banks. In fact, thirty or forty years ago, when the halibut were very abundant in Massachusetts Bay and in the waters about Cape Ann, but had no market value, they interfered

greatly with the work of the fishermen, and often good cod-fishing was spoiled by their sudden appearance. At the present time halibut occur in much smaller numbers on these grounds, and no such difficulty is noticeable. Indeed, it is found that cod occur in greater or less numbers with the halibut on the outer banks, where they seem to live peaceably together; and we are led to believe that it was the abundance of the halibut in former times, when they literally covered the ground, rather than any hostilities beween the species, that drove the cod from the banks.

Just how the large cod is affected by the presence of the pollock (*Pollachius carbonarius*) we are unable to say, but the young living near the shore finds in them its most deadly enemy. Young pollock are exceedingly abundant all along the shore during a greater part of the year, often moving in large schools as well as singly, and frequently many barrels are taken in a single day in each of the many traps along the coast. They are especially abundant in the waters off Cape Ann, and being exceedingly voracious, attack and devour almost any small fish that comes in their way. We have often watched their movements in the clear water of Gloucester Harbor, and noted the sudden dispersion of a school of several hundred young cod of six months' growth at the approach of a single pollock seven or eight inches in length.

These little fish show great fear of them, and usually remain near the long kelps and sea-weeds that are growing on the piling of the wharves, and at once dart in among these for protection at the first approach of the pollock, reappearing very cautiously only after the lapse of several minutes. At times a pollock succeeds in approaching unnoticed, when it suddenly darts into the midst of the school and seizes one of the little fish as its prey. Even when of equal size the cod exhibit the same fear, and on putting several of each about ten inches in length into a large tank of water, the cod sought refuge beneath some strips of board that were stretched across one corner, while the pollock swam about freely in the water. On being driven from their hiding place they soon returned, and it was not until the pollock were taken out that they would freely venture from their hiding place.

5.—REPRODUCTION.

Evidence is not wanting to show that cod spawn every year, and that they deposit the entire number of eggs in the ovaries each season. We have examined hundreds of specimens and have failed to find a single instance where the condition of the ovaries did not clearly indicate, to our minds at least, that such was the case. During the first of the season no mature fish were found in which eggs were not present, though they often varied greatly in development from very small to nearly ripe. Again, later in the season, no spent fish were seen with any eggs remaining in the ovaries; and no fish were found during the spawning period in which the condition of the ovaries did not indicate that the eggs were

gradually maturing, and would be deposited before the close of the season.

The eggs contained in the ovaries are separated into little irregular conical clusters, each connected with the general mass by a slender thread that expands into a delicate membrane containing minute and diffusely branched blood-vessels. This membrane incloses each of the eggs, and the blood-vessels supply the nutrition so necessary to their future growth and development. As the eggs mature they gradually increase in size, until, when ripe, they become detached from the membrane, and pass down through secondary channels into one main channel leading to the genital opening of the female.

The first ripe female seen during the season of 1878–'79 was found in a lot of fish landed from the shore-fish or ground-tenders September 2. The eggs were noticed to be running from this fish as it lay upon the floor of the fish-house. On opening it was found that it had just begun spawning, for a few eggs only, perhaps five per cent. of the entire number, were transparent, and a small number of these had separated from the membrane and fallen into the channels leading to the genital opening, while the great bulk were far less mature and represented almost every stage of development from green to ripe.

From this date ripe fish, both males and females, were occasionally taken, though they did not become abundant until the middle of October. Early in November, when the school-fish made their appearance on the south side of Cape Ann, the individuals varied greatly in their spawning condition; some were quite ripe and had already thrown a portion of their eggs, while others were so green as to indicate that they would not spawn for several months at least, though in nearly all the eggs had begun to enlarge. By the 1st of December fully 50 per cent. of the catch had commenced spawning, but when driven away, probably by the unusually heavy storms, in January, a few were not quite ripe, and the majority had not thrown all their eggs.

About the 1st of February the fish in Ipswich Bay were found to average fully 90 per cent. males, with the spermaries mostly well developed. At this time there was a great variation in the ovaries of the females; of these not more than one in ten had spawned, while fully 60 per cent. were still green. By the middle of the month the females numbered about 40 per cent., though over half had not commenced to spawn. On March 13, 300 fish from this school were opened, with the following results: 14 per cent. were spent males; 53 per cent. were ripe males; 6 per cent. were spent females; 14 per cent. were females in various stages of spawning, and 11 per cent. were green females. May 10, fully half of the females had not finished spawning, and an occasional green one was noticed. Even in June, when the fish left the coast, a very few, though ripe, had not finished throwing their eggs.

The results of the above observation prove not only interesting, but surprising, for we find the cod-fish spawning during nine consecutive

months in the same locality, a period far exceeding that required by any other species of which we have any knowledge.

This fact can be more easily understood when we remember that the individuals do not deposit all their eggs in a single day or week, but probably continue the operation of spawning over fully two months.

That this is true there can be little doubt, for when the females first begin to throw their eggs only a very small percentage of the whole number are ripe, while the balance show every gradation to the perfectly green and immature. By frequent examination of individuals in more advanced stages, it is found that the eggs gradually continue to increase in size as they mature, and that as fast as they become detached from the membrane they pass down through the channels to the opening, and are excluded from the body, either by the will of the parent or by internal pressure caused by the increasing size of the eggs, to make room for others. It would be impossible for a fish to retain all or even a small part of its eggs in the roe-bags until the last had matured, for the increase during the development is very great, and the eggs would come to have a bulk greater than the entire stomach cavity of the fish. The products of the ovaries of a 75-pound fish, after impregnation, would weigh about 45 pounds and measure nearly 7 gallons, equal to over half of either the weight or bulk of the fish.

Another proof that the cod-fish deposits its eggs gradually during a long period is seen in the fact that few can be taken from the fish at any one time. In "stripping the fish," at the hatchery in Gloucester, it was found that only one quart, or less than 400,000 eggs, could be taken from a 21-pound fish in a single day. Allowing the ovaries of this fish to contain 2,700,000 eggs, and the time of spawning to be two months, the fish must deposit in the natural way 337,500, or nearly a quart, each week.

But by the artificial method, where strong external pressure is applied, many more eggs are probably secured at once than would be naturally thrown by the fish. Thus the fish must either gradually deposit more or less eggs each day, during the entire spawning season, or it must deposit at intervals separated by only a day or two at most.

The schools move about but little during the spawning season, except when driven away by enemies or by violent storms. After they reach the waters of Cape Ann, fishing continues best in the same localities and even upon the same spots until they leave. The individuals, too, seem to move about but little among themselves. When the female becomes ripe she remains quietly near the bottom, while the male, a little more active, often swims higher up. This is indicated by the fact that much greater numbers of spawning females are taken with the trawl lying directly on the bottom than with the hand-line a little way above it, while the males are taken on one as readily as on the other.

It may not be impossible that the eggs are fertilized while floating about in the water some minutes after exclusion, and that the strong

tides usually found on the spawning-grounds play an important part in distributing the germs, thus making the chances of impregnation more favorable. Indeed it may be possible, and, if the spawning goes on gradually for several months, seems not improbable, that the immediate presence of the opposite sexes during the act of spawning is not necessary, but rather that the eggs are fertilized mainly by accidental contact. Observations would seem to strengthen the probabilities of this theory; for, if the fish went in pairs, they would often be taken on adjoining hooks of the trawl, or one on either hook of the hand-line. Such is not usually the case, however, but on the contrary several of the same sex are more frequently taken together.

The eggs have a specific gravity of 1.020 to 1.025, as indicated by the fact that they float in salt water and sink rapidly in fresh. The oldest fishermen had not the slightest knowledge of this fact, but held to the idea that the females deposited their eggs on the rocks, where they were visited and impregnated by the males, and left to become the food of the various animals so abundant in such localities. They had at times noticed the little transparent globular bodies in the water, but it had never occurred to them that they were the eggs of any fish. They may be found at the surface in common with eggs of the pollock, haddock, and probably other species of the cod family, when the sea is smooth; but when the water becomes rough they are carried to a depth of several fathoms by the current, though the tendency is to remain near the surface.

There are many ways in which these eggs may be destroyed. The principal loss is probably the result of non-impregnation, for unless they come in contact with the milt of the male very soon after being thrown from the parent they lose their vitality. Again, being subject to the winds and tides, they are often carried long distances from the spawning-grounds into the little bays and coves, and are driven upon the shores in immense numbers, or left dry by the tides, where they soon die from exposure to the atmosphere, or during the cold winter weather are instantly destroyed by freezing. Ipswich Bay, the most extensive spawning-ground in the locality, is especially unfortunate in this particular, for the heavy storms from the north and east tend to drive them upon the shore, and each breaker as it rolls in upon the beach must carry with it many millions of eggs.

But such impregnated eggs as escape destruction upon the shores are subjected to the ravages of the myriads of hungry animals living about the rocks and coves, and many are consumed. One day in January we introduced a jelly-fish or medusid, having a diameter of but 1½ inches, into a tray of eggs in the hatching-room, and in less than five minutes it had fastened 70 eggs to its tentacles, often loading them so heavily that they were severed from the body by the weight or resistance of the eggs as they were dragged through the water.

By the aid of a microscope, numbers of *vorticelli* were found upon them,

in one case 46 being counted on a single egg; and in addition a peculiar formation, thought to be minute algæ, was often noticed. Just what influence these latter would exert, or whether they would occur in the clear water outside the harbor, is not known. Thus, owing to the many different circumstances that tend to destroy the eggs, probably but a very small number out of a million are successfully hatched, and of the young fish but few reach maturity.

To overcome these difficulties nature has made the cod one of the most prolific of the ocean fishes, and we find not only thousands but millions of eggs in a single female. All members of this family contain large numbers of eggs, but the cod-fish is the most prolific of all.

The exact number varies greatly with the individual, being dependent largely upon its size and age. To ascertain the number for the different sizes, a series of six fish was taken representing various stages of growth from 21 to 75 pounds, and the eggs were estimated. Care was exercised that all should be green, so that no eggs should have been thrown and that they might be of nearly equal size. The ovaries were taken from the fish and accurately weighed; after which small quantities were taken from different parts of each and weighed on delicately-adjusted scales, and these carefully counted. With this data it was easy to ascertain approximately the number for each fish.

The results obtained are given in Table No. I, appended to this article, showing a 21-pound fish to have 2,700,000, and a 75-pound one, 9,100,000. The largest number of eggs found in the pollock was 4,029,200, and in the haddock 1,840,000. These facts are given in detail in Tables II and III.

When the eggs are first seen in the fish they are so small as to be hardly distinguishable, but they continue to increase in size until maturity, and, after impregnation, have a diameter, depending upon the size of the parent, varying from one-nineteenth to one-seventeenth of an inch. A 5 to 8 pound fish has eggs of the smaller size, while a 25-pound one has them between an eighteenth and a seventeenth.

From weighing and measuring known quantities it is found that one pound avoirdupois will contain about 190,000 of the smaller size, or that 1,000,000 eggs well drained will weigh about 5 pounds. Again, by assuming one-nineteenth of an inch as the standard, or by precipitating a known quantity in chromic acid and measuring, we find one quart, or 57¾ cubic inches, to contain a little less than 400,000, or that 1,000,000 will measure between 2½ and 3 quarts.

With these facts in mind, it will be an easy matter to estimate the quantity of eggs taken for hatching purposes during any given season.

When the little fish first break through the shell of the egg that confines them the fetal curve or crook is still quite noticeable, but they soon straighten, and are then about five-sixteenths of an inch in length. At this time the yolk-sack, situated well forward, is quite large, but so transparent as to escape the notice of the ordinary observer. This is

gradually absorbed, disappearing wholly in about ten to fifteen days, and the little fish begins to move about with a peculiar serpentine motion, at times darting quite rapidly, and then remaining motionless, as if resting from its exertions. It now begins its independent existence, and moves about more frequently, apparently in search of food. From this date it is impossible to follow them, for none have been confined, and it is only by catching large numbers at different seasons and carefully recording their weights and measurements that one is enabled to judge of their growth. The habits of the species, that cause them to live near the shore for the first few years, furnish excellent opportunities for such observations, and many were examined during our stay at Cape Ann.

At the outset the problem becomes difficult, in that the spawning period, instead of being limited to a few weeks, as is the case with most species, extends over fully three-fourths of the year, and the difficulty is greatly increased by special causes that affect the rate of growth of individuals hatched at the same time.

The results were what might be expected; for a table of measurements, made late in June, gave an almost continuous series, with only one or two breaks, that could with certainty be taken to represent the non-spawning period of the fish. But though the gaps were so completely closed by the extremes in variation, which seemed to cause even an overlapping, making the last hatched of one season smaller than the first hatched of the next succeeding, yet there was a tendency for the greater number of individuals to be thrown into groups at intervals in the series, these seeming to represent the height of the spawning season for the different years. The break was distinct between the smallest and those of a year earlier, so that, taking the height of the spawning season on the south side of the cape to be December, the large number of young fry ranging from 1½ to 3 inches must have been hatched the previous winter, and were consequently about six months old. The large number of individuals having a length of 9 to 13 inches indicated the normal growth of those hatched a year earlier, or fish of eighteen months to be 10 to 11 inches, and their weight 7 to 8 ounces. The next group, or the fish thought to be thirty months old, measured from 17 to 18 inches, with an average weight of 2 to 2¼ pounds. The fish now begin to increase more in weight than in length, soon appearing in the markets as "scrod," and by the following summer measure about 22 inches and weigh from 4 to 5 pounds.

Beyond this period nothing can be determined, for the variation, constantly growing greater, now gives every size and weight, with no indication of breaks in the series.

But enough has been learned, if the above be correct, to show that the male reaches maturity at three and the female at four years; for the smallest ripe male noticed during the season of 1878–'79 weighed 3½ and the smallest ripe female 5 pounds.

D.—HATCHING OPERATIONS.

1.—OBJECTS OF THE WORK.

Fish-culture, in its crudest forms, was first employed by the Romans and Chinese many hundred years ago; but the fish-culture of the present day, by which such excellent results are being obtained, is a science of recent growth, and it is only within the past few years that it has assumed a thoroughly practical aspect. Its present condition is the result of a continued series of experiments that have given a degree of success far beyond what its most enthusiastic workers had dared to expect.

The present shad-hatching apparatus, that seems so near perfection, is an excellent example; for in this case, though the progress has been rapid, the crude apparatus of a few years ago has been replaced by the new only after the most careful experiments with the eggs of the species. So with other fresh-water and anadromous species; the improved apparatus for successfully hatching them is the result of many experiments and observations.

But, while the above species have been the subjects of careful study, the important marine food-fishes, such as the cod, halibut, and sea-herring, have remained unnoticed. The great importance of these fisheries has led Professor Baird to consider carefully the question of the artificial propagation of several of the principal species, and, after studying the habits and food of the fish for some time, he decided to inaugurate a series of experiments to ascertain what could be accomplished in this direction.

Accordingly, a hatching station was established at Gloucester in the fall of 1878 for the purpose of experimenting with the eggs of the cod, in order to learn how and in what numbers they might be obtained, the kind of apparatus necessary for successfully hatching them, and to what extent artificial propagation might be made practicable. The chief aim was then to study experimentally the whole subject of hatching in its relations to the cod-fish and its eggs, to pave the way for future work, rather than to go into any extensive work for the immediate propagation of the species.

2.—PREPARATIONS FOR HATCHING.

The late James W. Milner, deputy commissioner, arrived early in the fall to take charge of the experiments, and Mr. Frank N. Clark, a professional fish-culturist in the employ of the Commission, came soon after to personally superintend the work in the hatching-room. Mr. Milner remained long enough to see the preliminary apparatus and machinery placed in position and the first eggs taken, when he was obliged to return to Washington on account of his serious sickness. A little later Mr. Clark was called away to look after the interests of the Commission in another State, and Capt. H. C. Chester superintended the work in the hatchery during the remainder of the season.

The building occupied by the Commission during the summer as a scientific station was considered suitable, and was retained for the work. It is situated at a prominent point, on the southwest side of the harbor, on a substantial wharf, with 4 to 6 feet of water at mean low tide. The outer end of the building was set off as a hatching-room, the remainder of the lower part being used as a store-house, while the upper part answered the purpose of an office and laboratory.

A 4-inch pipe was laid from the hatching-room to a point in the harbor at the end of the wharf, and sunk below low-water mark. The outer end of this pipe was fastened to the piling of the wharf, and incased in a box with wire-cloth openings to keep out the animal life of the harbor. The inner end communicated with two 300-gallon tanks, placed in an elevated position in the center of the room, to be used as reservoirs for the salt water. These reservoirs were tapped from beneath by smaller pipes that extended along the walls of the building, at a height of 4 or 5 feet, with faucets at short intervals, from which the water was supplied to the eggs by means of rubber tubing. In one end of the room was an 8-horse-power steam-engine, for working the pump that brought the water from the harbor to the reservoirs in a constant stream, the quantity being regulated by the outflow.

It was of course unknown what hatching-apparatus could be successfully used, as no eggs of the cod had ever been artificially hatched; and indeed it was not then quite clear to the minds of those in charge to which of the three classes, sinking, floating, or adhesive, the eggs of the cod belonged. Cones similar to those used in shad-hatching (figured in the Report of the Commissioner of Fish and Fisheries for 1873–'74 and 1874–'75, p. 376) were selected as likely to give the best results, put up along the sides of the hatching-room, and connected with the faucets by the rubber tubing.

The above constituted the original apparatus of the hatchery, and when it had been properly arranged Mr. Milner turned his attention to the methods for securing the supply of fish and eggs. For this purpose he selected a 5-ton schooner and a 14-foot open market-boat for visiting the fishing-grounds, and, in addition, a small well-boat in which the fish could be brought alive to the hatchery. A little later it was found desirable to build large live-boxes for confining the green fish until they should ripen.

These live-boxes were 12 to 14 feet long, 6 feet deep, and 5 feet wide, made of pine lumber, with 2-inch spaces between the narrow boards, to admit a fresh supply of water to the fish. When finished they were anchored in the harbor beside the wharf, where they remained throughout the season.

3.—MANNER OF PROCURING EGGS.

The supply of eggs was obtained in several different ways during the winter.

The first method employed was to send men to the fish-wharves daily to examine the fish landed and to take the eggs from any ripe females that might be found. This practice was soon given up, as the fish had usually been dead some hours when they were landed, owing to the distance of the fishing-grounds from the harbor, and the eggs had so nearly lost their vitality that they could not be impregnated. Only an occasional lot of fish were found whose eggs could be saved, and few good ones were obtained in this way.

A second method, by which the men went daily in the schooner to the fishing-grounds to take eggs from such ripe fish as they might catch, was pushed vigorously at first. In this case hand-lines were used, as the bottom was too rocky for trawling, and the catch was composed largely of green fish, so that few eggs were obtained.

A third method, which was merely a repetition of the second on a larger scale, was more successful in that more fish were taken, and consequently more ripe ones found. The plan was to utilize the catch of the fishermen by putting spawn-takers on several of the regular fishing-schooners to examine each fish as it came from the water, or as soon as it was brought to the vessel, and to bring the ripe eggs to the hatchery in pans taken out for the purpose. This method was followed during a greater part of the time, and some good eggs were obtained in this way. But here as in the former case hand-lines were used, and spawning fish were not taken in very large numbers. A visit to the fishing-grounds, where trawls were used, later in the season, fully convinced us that as many eggs could be obtained in this way as might be needed, for on a four days' trip to Ipswich Bay, in February, many millions might easily have been secured.

The finding of so many green fish led to the building of the live-boxes at the hatchery, and when these were ready the schooner visited the fishing-grounds daily and brought her catch alive to harbor in the little well-boat, transferring the fish at once to the live-boxes, where they were to remain until they should ripen. These live-cars proved a great success, for the fish kept well and ripened rapidly. In this way many live fish were kept convenient to the hatchery, where they could be carefully watched, and the eggs secured as soon as they had ripened. This method entirely overcame the difficulties of bringing the eggs long distances and of properly caring for them until they could be transferred to the hatching apparatus, and the live-cars soon came to furnish nearly all the eggs.

4.—HATCHING OPERATIONS.

Two spawn-takers visited the live-cars at intervals of one to three days, one taking out the fish with a dip-net, while the other examined them carefully, by pressing gently on the abdomen, to see if they were ripe. If green, they were transferred to an empty live-box floating beside the other; but when a ripe fish was found it was confined in a dip-

net and returned to the water until one of the opposite sex could be secured. Thus all the fish were examined regularly every second or third day, and when ripe ones were found they were carried to the hatchery, where the eggs were taken and impregnated.

In "stripping" the fish the spawn-taker usually held its head firmly in his left hand, with its back against his body and its left side uppermost, and, owing to its size and strength, a second party generally held the tail and helped to keep the fish in position, while the spawn-taker, with his right hand, gently pressed the eggs or milt from the abdomen into a large pan placed just beneath to receive them.

The methods employed in impregnating the eggs were similar to those in use with eggs of the shad. They were usually taken in a pan having a little water in the bottom and the milt at once added, after which they were "brought up" in the usual way, by slowly adding water at intervals till the pan was nearly full.

It was found desirable to leave the eggs with the milt for fully half an hour before dipping them out, and at times it took even longer for them to become well hardened. Several other ways for impregnating the eggs were tried, such as taking them in a damp pan and introducing the milt directly upon them before adding the water; and of putting the milt in the water first, and the eggs later; and again, of introducing the two at the same time; but these seemed no improvement upon the ordinary method.

The first good eggs were taken November 13, and when placed in the cones were found to remain constantly at the surface of the water, where they soon clogged the screen through which the waste water made its escape, causing the cones to overflow, and the eggs to be carried over the top with the water. The plan of introducing the water at the top and allowing it to escape at the bottom was equally unsuccessful, for the downward current carried many of the eggs with it, thus clogging the screen as effectually as in the former case. The cones in their original condition were thus rendered useless, and the question of so modifying them as to make them answer the purpose, or of the invention of new apparatus, at once became a very important one; and one difficulty after another had to be overcome before any degree of success could be expected.

Mr. Milner remained long enough, before leaving for the South, to witness this stage of the difficulty, and was the first to suggest an alteration in the apparatus. This consisted in a modification of the inverted cone, so that the water should be introduced through a twisted tube at the apex, thus giving it a spiral motion as it ascended, while the outflow was in the form of a circle surrounding and just above the inflow, in a line with the sides of the cone. On testing, this apparatus was found to clog equally with the other, and was soon abandoned.

In one end of the room was a Clark hatching-trough that had been used in hatching eggs of the herring. This consisted of a long trough

about 12 inches square, with numerous partitions dividing it into a number of compartments. The whole was placed at an incline, so that the overflow of water from one compartment would run into the next lower through a little groove at the top of the partition. Mr. Clark introduced into each compartment a small wooden box with a wire-cloth bottom, each to be placed at an angle with the bottom of the trough, with its lower end under the little spout that conducted the waste-water from the compartment above. With the box thus placed in a compartment filled with water, the stream that was kept constantly running would fall into its deepest part, and in this way create considerable current in the water, the surplus gradually passing out through the bottom and up around the sides on its way to the next compartment.

When the cod-fish eggs were introduced into these boxes they were found to have an excellent motion; but of the great amount of harbor sediment and mud in the water much was retained in the boxes by the wire screens and gradually collected on the eggs, causing them to sink to the bottom, where they soon died. This apparatus, though seemingly all that could be desired with clean water, was rendered useless by the fine dirt that could not be kept out.

The writer suggested a modification of the copper cone, so that the water should escape near the top through an intermittent siphon, the end of which should be incased in a large wire-cloth bag, to weaken the strength of the current where it met the screen, and cause any eggs that might be held against the bag while the water was running to fall away when it stopped. This apparatus, like that of Mr. Clark, was rendered useless by the sediment in the water; and in addition, there seemed to be a corrosion of the copper, due to the action of the salt-water, that proved injurious to the eggs.

The Ferguson bucket, which consists of a cylinder of sheet-iron, with a wire-cloth bottom, getting a circulation of water by means of a slow rise and quick drop when partially immersed, was tried, with only indifferent results.

Captain Chester was at this time devising an apparatus which should not only give a certain change to the water, but also partially keep the sediment from the eggs. This apparatus is known as the Chester bucket. It consists of a tin cylinder 18 inches in diameter and 24 inches deep, with four rectangular openings, each $2\frac{1}{2}$ inches wide, extending from near the bottom to within 5 inches of the top. These and the bottom of the cylinder are covered with wire-cloth, to prevent the eggs from escaping and the dirt from entering.

On the outside of the cylinder, along one side of either opening, are placed strips or pockets of tin, at an angle with the side, and extending partially over the openings, so that the adjacent pockets face in opposite directions. As the cylinder rotates on its axis, the water is forced in at the two opposite openings and out at the others.

Beneath the wire-cloth bottom are four more strips of tin, radiating

from the center, and placed at such an angle that the rotation of the cylinder forces the water against them, and up through the bottom. The whole is placed in a trough nearly filled with constantly-changing water, and sunk to such a depth that the water nearly fills it. The cylinder turns on a pivot, the power being applied from the engine by means of shafting, to a horizontal arm firmly fixed to its axis, and is kept constantly turning back and forth through an arc of 90°, thus keeping the water changing, and giving the eggs a tendency toward the top center.

When this apparatus had been thoroughly tested, and found to give good results, the cones were taken down, and water-tight troughs placed along the sides of the hatching-room to receive the Chester buckets, and from this date the hatching operations were conducted with a fair degree of success; and while, with pure water, the modified Clark trough or some equally simple apparatus might give excellent results, yet to Captain Chester belongs the credit of having partially overcome the existing difficulties, and of inventing the first apparatus successfully used in hatching floating eggs.

The time required for the development of the eggs of the cod-fish, after they are thrown from the parent, varies greatly, being dependent largely upon the temperature of the surrounding water. Of those taken November 13, the first hatched in 13 days; while of those taken December 17, the last did not hatch until February 5, thus requiring 51 days; giving a difference of 38 days for eggs taken within little over a month of each other. The period of 51 days represents an extreme case, and the circumstances may be worthy of consideration. These eggs, as above stated, were taken December 17 from four fish apparently in good condition, and placed in a bucket in the hatchery. January 28, the bucket was thought to contain too many eggs, and a few were taken out and placed in a floating box, with wire-cloth bottom, anchored in the harbor. The difference in temperature of the water in the two places averaged from one to two degrees.

Of those remaining in the building, the first hatched January 17, and the last on the 23d, making a variation of 6 days.

On January 25, the first fish were noticed from the harbor lot, and from that time they continued to hatch slowly until February 3, when not more than 10 per cent. were out, and 2 days later, when the first fish were 11 days old, and the eggs 51 days from the parent, a few still remained unhatched.

The variation of 11 days for eggs treated in exactly the same manner, suggests the idea that other elements than temperature may enter in to hasten or retard development. One cause, namely, that of the condition of the eggs when thrown from the parent, may considerably affect this period.

We find with the cod, as with other species, that the first fish hatched from a given lot of eggs always seem weak and immature; and again,

that the last are usually in the same condition. The first are perhaps from eggs that for some reason have remained in the parent after they should have been thrown; the great majority of healthy fish coming later probably represent eggs in their normal condition; and the weak ones hatching last may be from eggs, that, though not thoroughly matured when taken, had just reached that stage where impregnation became possible. The time elapsing after the eggs leave the fish before they come in contact with the milt may also affect the time of hatching.

Experiments in these lines would be of practical importance in determining how many good eggs could be taken from the fish at one time; how often eggs might be taken from the same individual, and, also, the most desirable time for applying the milt.

A table of temperature observations, showing the condition of both air and water at the first high and low water after 7 a. m., will be found further on. The temperature of the water in the hatchery was always from one to two degrees higher, being raised a little in passing through the pipes. From this table we find that the average time required for hatching eggs, in water of different temperatures, was as follows:

	Days.
In water having an average temperature of 45° F.	13
In water having an average temperature of 41° F.	16
In water having an average temperature of 38° F.	20
In water having an average temperature of 36° F.	24
In water having an average temperature of 34° F.	31
In water having an average temperature of 33° F.	34
In water having an average temperature of 31° F.	50

The water of the harbor reached, and remained for a number of days, at a temperature of 30°, but the eggs in the floating box remained uninjured, even though the little fish in them were well advanced, while the large cod in the live-boxes within a few feet of them were all frozen to death.

Several attempts were made to hasten the development of the egg, by raising the temperature of the water by means of steam-pipes. The time of hatching was frequently shortened in this way, but in all cases the fish seemed premature and soon died. The failure in these experiments may be due to the crude apparatus that could not be regulated so as to keep the temperature constant and avoid fluctuations. These difficulties overcome, it seems not at all improbable that the process of hatching could be materially shortened, and the fish gradually accustomed to cooler water until the natural temperature of the harbor should be reached, when they could be put out.

The problem of hastening or retarding development in the egg is a very important one. Fish-culturists have given some attention to the subject, but none have yet succeeded in the invention of apparatus by which the water can be kept constantly at any given temperature.

Ripe fish were found nearly every time the live-boxes were overhauled,

from November 13 to early in January, when the fish were frozen. Forty-three females were "stripped" during the season, and the milt from 60 males was used in fertilizing their eggs. The total number of eggs secured in this way was about nine and one-quarter millions.

It may be a matter of some surprise that so few eggs should be obtained from so large a number of fish; but it must be remembered that the eggs ripen slowly through a period of six to ten weeks at least, and that but few can be secured at any one time. Probably not over 200,000 can be taken from a 10-pound fish in a day, while 400,000 would be a large average for a fish of 20 pounds weight. After the fish were once "stripped" they were allowed to die, as the primary object of the experiments was methods, rather than quantities of eggs. In this way the great bulk and number of eggs were not secured; but when the work shall be resumed for the purpose of increasing the food supply, we see no reason why these spawning fish may not, by exercising care, be "stripped" over and over again until all or at least a greater part of the eggs have been secured, the fish being returned to the live-boxes after each operation. Still the supply of spawning fish seems limited only by the size of the live-cars, and the above method may not become necessary.

About the 1st of January the weather became quite cold, and the temperature of the water on the night of the 3d, for the first time during the winter, fell to 30°. On the morning of the 4th, when the spawn-takers visited the live-cars, they found that all the fish had been frozen to death, and, on examination, considerable ice was noticed in their stomachs. At this time the more important points about the treatment of the eggs having been learned, and the practicability of artificial propagation fully established, it was thought unnecessary to secure a new stock of fish for the live-cars, and it was decided to discontinue operations until such time as they could be resumed on a steamer constructed especially for the purpose. By this means the harbor sediment can be avoided, and the fish followed to any locality where they chance to be most plenty.

The number of fish hatched during the experiments was not far from 1,550,000. At first, while the apparatus remained so imperfect, the loss was great, and nearly or in some cases quite all of the first few lots of eggs were killed. But with the introduction of new methods one difficulty after another was overcome, and the percentage of loss was gradually reduced. The manner of caring for the eggs while hatching soon came to be better understood, and this too had a decidedly beneficial effect; so that, barring the loss resulting from impure water, there was a constant gain in the percentage hatched, and the loss during the last of the season did not exceed 40, and was frequently not over 30 per cent.

When first hatched, the little fish remain nearly motionless, or, at times, indulge in the same spasmodic efforts so noticeable when freeing themselves from the eggs. In a day or two they become more active, darting about for short distances in the water, with a peculiar motion and considerable rapidity. In a few days they begin to absorb the

yolk-sacks, and seem quite vigorous, while the pigment-cells increase rapidly, giving them considerable color. When they had reached this stage, they were usually taken to the outer harbor and liberated, to become accustomed to their future surroundings before the yolk-sacks were absorbed, thus giving them the opportunity of seeking their natural food when the first instincts of hunger should lead them to desire it.

The young cod seem more hardy than those of most other species, and may be kept for a considerable length of time with small loss. In one case fully 50 were put in an 8-ounce bottle and kept in a room at a temperature of 50° F., without change of water, for four days, before the first ones died. Early in January a number were sent by express to Professor Baird in Washington, where they arrived in good condition, with no care on the way except that given by the baggage-master on the train.

5.—DIFFICULTIES ENCOUNTERED.

The difficulty of suitable apparatus for hatching the eggs has been fully described. This consisted not only in the invention of something suitable for floating eggs, but an apparatus that could be used in impure water. These requirements, after several unsuccessful attempts, were at last met, and the difficulty partially overcome by the introduction of the Chester bucket.

The greatest source of annoyance, and one that could not be wholly overcome, was the abundance of the harbor sediment or dirt in the water. The trouble from this source was due largely to location. The hatchery was situated at a point of the harbor, with the main channel on one side, and on the other a large cove, into which the refuse of much of the business portion of the city found its way through the street gutters and sewers. The location of the hatchery was then unfortunate, in that it occupied a position where the main current caused by the 11-foot tide, on its passage in and out from the cove, brought a greater part of the dirt and filth of the city directly beneath and beside the wharf, where much of it was pumped up through the pipes into the hatching-room, and found its way to the eggs.

In addition to this, the violent storms caused a heavy undertow to roll in from seaward, and to stir up the mud from the bottom and sides of the harbor, so that at low tide the water was often quite thick. This sediment of course passed up through the pipes, and often resulted in great injury to the eggs. It was not unfrequently the case that a lot of eggs would continue in good condition until the fish were nearly ready to hatch, when a heavy storm would roil the water, and cause the dirt to collect on them to such an extent as to give them a dull brownish color, and from its weight sink them to the bottom, where they soon died.

Every precaution was taken to thoroughly cleanse the water from these impurities before it came in contact with the eggs. Large flannel filters were introduced, and all the water made to run through several of

them on its way to the reservoirs. During stormy weather, when the bottom mud was stirred up, the water was often passed through six or seven of these filters, but even then the finer sediment could not be kept back. Frequently the dirt was pumped up in such quantities as to so completely clog the filters that the water would not go through them, and at such times they had to be replaced by clean ones every few minutes during the hours of low water. Other methods of filtering were also tried with no better success.

The new Fish Commission steamer, built expressly for this work from a special appropriation of Congress, will entirely do away with this difficulty resulting from impure water, as she can be safely anchored in the deep water of the outer harbor where no sediment is found.

The corroding action of the salt-water upon the copper and tin of which the apparatus was made, was also the source of considerable trouble. The copper cones were rendered useless on this account, and tin was often eaten entirely through in a few days. This difficulty was partially overcome by thoroughly painting the cones with asphalt, but even then the tin would rust so badly as to seriously injure the eggs. All trouble from this source can be easily avoided in future by making the apparatus of wood or some metal that is not acted upon by the salt-water. Indeed, nickel wire-cloth was used during the latter part of the season for the bottoms of the buckets, and found to answer the purpose admirably.

The fact that the cod cannot live in water colder than 30° F. presents another difficulty, for it is of the utmost importance that a large supply of fish be kept constantly in the live-boxes; and, as the water at the surface of the harbor may reach this temperature at any time for several months during mid-winter, the fish are liable to be frozen. But with a steamer anchored in several fathoms of water in the outer harbor, the live-cars by her side could, at the approach of cold weather, be weighted and sunk to the bottom until the weather should become warmer.

6.—EXPERIMENTS WITH EGGS OF OTHER SPECIES.

While the primary object of the station at Gloucester was for the study of the cod, the question of the reproduction of several other important species received considerable attention, and much valuable information was gathered. Among these species were the haddock (*Melanogrammus æglefinus*), the pollock (*Pollachius carbonarius*), and the herring (*Clupea harengus*).

a. Herring.

Herring visit different parts of the coast from Cape Cod to Labrador at various seasons of the year for the purpose of spawning or feeding, and are abundant in some localities during a greater part of the summer.

In the winter the herring-fisheries of Newfoundland and Nova Scotia are very extensive; and formerly the spring herring-fisheries of the

Magdalen Islands drew a large fleet to that region. The fall fishing is most extensive in the vicinity of Wood Island (near Portland, Me.), and on the south side of Cape Ann, where herring "strike in" along the shore in immense schools, about the middle or last of September, for the purpose of spawning. At such times small vessels, from almost every fishing town between Cape Cod and Eastport, visit these localities with gill-nets, and the fish are sometimes taken in such numbers as to sink the net. At Wood Island alone, in the fall of 1879, the herring fleet numbered over 150 sail.

While preparing for the cod work at the hatchery a small school of spawning-fish arrived in the vicinity of Gloucester Harbor, and it was decided to make experiments with their eggs. Accordingly, the Fish Commission boats were provided with nets, and, for about two weeks beginning with October 12, visited the spawning-grounds daily, setting their nets in the evening and fishing them over at intervals through the night. Ripe males were always plenty, and 50 spawning females were sometimes taken in a single night. Many thousands of eggs were secured in this way, and after impregnation were taken to the building, where large numbers were successfully hatched.

The eggs of this species are adhesive, and when thrown into the water by the fish fasten themselves to the first hard substance with which they come in contact, this being usually the algæ or the rocky bottom. On account of their adhesiveness, when taken from the fish for hatching purposes, they must at once be brought in contact with that particular object on which they are to remain till hatched, as when they have become fastened to any substance it is impossible to remove them without injury. For the purpose of bringing them from the fishing-grounds, a water-tight egg-box was made, with slits or grooves in the sides, to receive movable panes of glass, and keep them in position until they could be transferred to the apparatus in the hatchery.

As soon as the fish were taken from the water the eggs were pressed from them upon these panes of glass, and, after the milt had been applied, were quickly spread over the surface by means of a feather. The glasses were then placed in position in the egg-box and the water was changed at short intervals until they arrived at the hatchery.

A Clark hatching-trough (described on page 37) was arranged with grooves on the sides of the compartments to receive the glasses of eggs, these being three-fourths of an inch apart and placed at an angle with the perpendicular. The glasses were so arranged that every alternate one should rest on the bottom, with the others half an inch above, so that the water must pass over the top of the first pane, under the second, over the third, &c., on its way through the trough, thus giving a constant stream over each pane. A few eggs were taken on wire cloth and others on mosquito netting, but the former rusted so badly as to injure the eggs and the latter collected such quantities of sediment from the water that the results were far from satisfactory. Those taken on

the glass did much better, as the eggs could be washed with a camel's hair brush or a feather, and thus kept passably clean.

The development of the eggs was quite marked, and the line of the fish could be distinguished at the end of the third day; the eye could be seen on the fifth, and on the sixth a very slight motion was noticeable. The average time in hatching was about twelve and the shortest ten days.

The greatest difficulty encountered in this as in other cases was from the impure water; but, even under these circumstances, a good many were hatched, and the experiments proved conclusively that the artificial propagation of the species would be an easy matter if at any time it should be thought desirable.

b. Pollock.

Large pollock are absent from the waters of Cape Ann from the middle of January till early in May, the small ones leaving earlier in the fall and returning in April. The young may be taken almost anywhere along the shore, but the large fish seem to confine themselves to definite localities; and though not particularly abundant during the summer at Cape Ann, it is a favorite spawning-ground for the species, and during this period large schools visit this shore.

They begin to grow plenty about the first of October, and by the last of the month are so numerous as to greatly annoy the cod-fishermen by taking the hook before it can get to the bottom.

During this season some of the smaller vessels fish exclusively for pollock, "seizing" up their lines a number of fathoms from the bottom, and at times the fish bite as fast as the fishermen can haul them. Early in November, a crew of four men landed 10,420 pounds, or about 1,100 fish, the result of less than two days' fishing. Owing to a foolish prejudice, the price is always low, at times being less than 30 cents per 100 pounds. The average weight of the fish is about 9 or 10 pounds, and during the spawning season the sexes are taken in about equal numbers.

They seem to spawn while swimming about in the water, and their eggs, being buoyant, are found at the surface with those of the cod; but they may easily be distinguished from the latter by their smaller size. The first ripe female was seen at the fish-wharves October 23. November 11, a few good eggs were taken, and, after impregnation, found to have a diameter of one twenty-fifth of an inch. They were placed in an aquarium at the hatchery, and within forty-eight hours the fish could be distinctly seen, though no pigment cells were visible. This proved that the development of the eggs after leaving the parent was quite rapid, and indicated that they would hatch in five or six days at most, with water of the ordinary temperature.

At the time of taking these eggs no suitable apparatus had been arranged, and we did not succeed in hatching them; and as no others were obtained during the season positive statements cannot be made;

but the eggs were well advanced before they died, and careful observations up to this point fully convinced us that these eggs are as hardy as those of the cod, and that they may be successfully hatched by a similar method.

Table III gives the result of our computation of the number of eggs in individuals of different size, from which it will be seen that a 23½-pound fish has over 4,000,000 of eggs, while a 13-pound one has 2,500,000.

c. Haddock.

It is not many years since haddock were very little sought in the markets, and the price averaged only one cent each; but the method of smoking them, introduced into this country by the Scotch, has greatly increased the demand, and now a ready sale can be found for any quantity at good figures. At the present time a large fleet of Gloucester and Portland vessels are engaged in this fishery during the winter months, visiting George's and other offshore banks, and localities further north where the fish are abundant at this season. The vessels are each provided with trawls, and a single crew have been known to take nearly 20,000 pounds in a day.

The fish usually remain on these offshore banks till the winter is over, and they do not reach Cape Ann until just before the spawning season, which for this species begins about the middle of April and continues during nearly three months, the height of the season being in May.

In the spring of 1879 it is thought that two schools visited this coast, the first, composed of fish of large size, arriving early in April and leaving by the middle of May; and the other, composed of smaller fish, reaching the grounds about the 20th of May and leaving gradually after the 1st of July, a few remaining during the greater part of the summer. When the fishing first began, the fish were several miles from the shore, but they continued to "work in," until there was good fishing at the mouth of the harbor for several days, after which they seemed to move back again, and toward the close of the season remained on muddy bottom, when trawls were extensively used in their capture.

Early in May haddock were so plenty that one man caught 1,881 pounds in one day with hand-lines, and about the same time many different fishermen secured over 1,000 pounds. The males were usually a trifle more abundant, though at times the females composed fully half of the catch. The latter average larger than the former, and some days there would be a difference of two pounds in favor of the female.

The first ripe females were noticed on the 23d of April, and in the middle of July an occasional fish had not finished spawning. The first eggs were secured May 5, and others were taken at intervals to June 2, the total quantity being about 250,000. The method of impregnation was similar to that used for eggs of the cod, and the size of the eggs was one-nineteenth of an inch. Though the number contained in the

larger individuals of the species reaches over 1,800,000 (see Table II), the quantity obtained for hatching purposes at any one time was quite small as compared with the number taken from the cod or the pollock, and the quantity of milt in the male fish was very much less than in either of the other species.

Different methods were employed in hatching the eggs; among others the Clark trough, and a floating box with wire-cloth bottom placed in the harbor beside the wharf. Those placed in the former were injured by dirt, but the floating box was more successful, and of the eggs placed in this a number were hatched. The line of the fish could be seen when the eggs were three days old, and in five days the fish was fully formed, though no motion could be detected. The shortest time required for hatching was eight, and the average nine days.

7.—CONCLUSIONS.

Up to the time of the establishment of the hatchery at Gloucester, so far as we know, no attempt had been made to impregnate and hatch floating eggs, and the whole subject involving the artificial propagation of so many important species had received little attention from the fish-culturists of the world.

The results of the experiments, during the three or four months of the winter of 1878–'79, were all that had been expected, and gave methods that will be of the greatest value for future extensive work. The principal points involved in hatching this class of eggs are now fairly understood, and most of the difficulties in the way of success have been met and overcome.

That the artificial propagation of the species is not only possible but practicable is proven by the fact that, under the most unfavorable circumstances, a small party succeeded in hatching over a million and a half of young cod during a short season; and that the loss of eggs in hatching was reduced from 100 to only 30 per cent. in about two months.

With apparatus made of suitable material, and placed on the new steamer now being built for the purpose, we see no reason why the work may not be carried on with the utmost success. At Gloucester the steamer can be safely anchored in the deep water of the outer harbor, away from all dirt and sediment, and can, if necessary, be moved to any other place where the fish chance to be more plenty.

With other species hatched by the Commission the great difficulty has been to secure the spawning-fish, from which the supply of eggs could be obtained. This has required a large force of men kept constantly on the fishing-grounds, and even then the quantity of eggs taken has usually been below the desired number, so that the hatching operations have often been limited by the number of eggs that could be secured. Again, with most species the spawning season for any particular locality lasts but a few weeks at most, and the loss of time occasioned by storms and other causes frequently interferes greatly with the success of the work.

With the cod the case is wholly different, for fish are plenty on the New England coast during most of the year, and the spawning season at Cape Ann lasts during eight or nine months.

The supply of spawning-fish can be obtained with little difficulty by a single crew, and brought to the harbor alive from any locality desired by means of an ordinary market well-smack.

These fish can be transferred to the live-cars convenient to the hatchery, to remain until such time as they may ripen. Thus the live-cars can be made a source of almost constant supply, and the hatching operations can be vigorously pushed during fully half the year; while the number of fish that can be hatched seems limited only by the capacity of the hatchery, and hundreds of millions of eggs can easily be secured in a single season.

The young fry seem quite hardy, and can be kept confined a considerable time and transported long distances with small loss; so that it will be an easy matter to carry them to the more southern waters before turning them loose in the sea. In this way it is thought that the range of the commercial fisheries may be somewhat extended, and a large class of people, both fishermen and consumers, greatly benefited. When the subject is regarded from the above standpoint, it is clear that the artificial propagation of the cod, as well as that of several other species, will remove the possibility of the extermination of these species from over-fishing; for the ovaries of 25 good-sized cod-fish, if all the eggs were hatched, would furnish more fish in number than are taken by the combined fleets of cod-fishermen from all the different fishing-ports of the United States during the most prosperous season.

SMITHSONIAN INSTITUTION, *February* 1, 1880.

E.—APPENDIX.

TABLE I.—*Showing the number of eggs in cod-fish of different sizes.*

Number.	Length of fish.	Weight of fish.	Weight of ovaries.	Estimated weight of ovary-walls.	Net weight of eggs.	Number of troy grains weighed out.	Number of eggs in the portion weighed out.	Number of eggs to the grain.	Total number of eggs in fish.
	Ft. In.	*Lbs.*	*Lbs. Oz.*	*Oz.*	*Lbs. Oz.*				
1	.....	70–75	8 8	6	8 2	7	1,108	160	9,100,000
1 (*a*)*	.....	70–75	8 8	6	8 2	7	1,132		
2†	4 2½	51	7 2	5	6 13	6	1,131	188.5	8,989,094
3	3 8	30	2 8½	2½	2 6	6	1,341	223.5	3,715,687
4	3 5	27	2 9½	2½	2 7	7	1,680	240	4,095,000
5	3 4½	22¾	2 2½	2	2 0½	6	1,368	228	3,229,383
6	3 3	21	1 15½	1½	1 14	6	1,249	208.17	2,732,237

*No. 1 (*a*) represents a second quantity taken from the same ovary the following day, and the greater number may be partially accounted for by the evaporation of moisture during the night.

†No. 2 contained a few ripe eggs.

TABLE II.—*Showing the number of eggs in haddock of different sizes.*

Number.	Length of fish.	Weight of fish.	Weight of ovaries.	Estimated weight of ovary-walls.	Net weight of eggs.	Number of grains (troy) weighed out.	Number of eggs in part weighed out.	Number of eggs to the grain.	Total number of eggs in fish.
	In.	*Lbs.*	*Oz.*	*Oz.*	*Oz.*				
1	28¼	9 3/16	9½		8⅝	4	1,950	487.5	1,839,581
2	26½	6 1/16	5¾		5¼	4	1,479	369.75	849,315
3	26	6 1/16	6		6	4	1,457	364.25	856,156
4	24	4 1/16	6		6¼	5	1,160	232	634,880
5	22	4	5		4¾	5	970	194	408,132
6	20¾	3 3/16	5		4¾	5	960	192	398,976
7	19¼	2 5/16	2		2	5	966	193.2	169,050

TABLE III.—*Showing the number of eggs in pollock of different sizes.*

Number.	Length of fish.	Weight of fish.	Weight of ovaries.	Estimated weight of ovary-walls.	Net weight of eggs.	Number of grains (troy) in part weighed out.	Number of eggs in part weighed out.	Number of eggs to the grain.	Total number of eggs in fish.
	Ft. In.	*Lbs.*	*Lbs. Oz.*	*Oz.*	*Lbs. Oz.*				
1	3 8½	23½	2 2	2	2 0	6	1,727	287.8	4,029,200
2	2 8½	13	1 2¼	1¼	1 1½	6	2,043	340.5	2,509,753

TABLE IV.—*Showing the variation in weight of cod-fish of various lengths.**

MALES.

Length of fish.	Condition of spermaries.	Weight of fish.	Length of fish.	Condition of spermaries.	Weight of fish.
In.		*Lbs.*	*In.*		*Lbs.*
16⅜	Very small	1¾	33		13¾
20		3	33	Very small	13¾
21	Nearly ripe	2¾	33⅛		0¼
23	Very small	4⅛	34	Medium	14
24	Small	4	34	Nearly ripe	14
24½	Large	5¼	35		12
25	Nearly ripe	5¼	35		13
26	Very small	6¼	35	Well developed	15⅝
27	Well developed	8¼	35⅛	Small	13½
27	Very small	7¼	35⅛	Well developed	15½
28	Well developed	7 3/16	36		12¾
29		8	36	Medium	14¾
30		7	36	....do	15
30	Small	9¼	36½		16⅛
30		8¾	38		17
30	Nearly ripe	8½	40	Well developed	19
30	....do	10¼	40	....do	21
31	Ripe	9¾	40	....do	21¼
31	Small	8¾	40⅛	Medium	20¾
31		7	40⅜		25
31½		8½	42	Well developed	23½
31⅝	Well developed	10	42	....do	24¾
31⅝	....do	10¾	43	Medium	25¾
33		11	46	Well developed	43
33	Medium	11¼			

*The measurement was to the end of middle caudal rays.

TABLE IV.—*Showing the variation in weight of cod-fish of various lengths*—Continued.

FEMALES.

Length of fish.	Condition of ovaries.	Weight of fish.	Length of fish.	Condition of ovaries.	Weight of fish.
In.		*Lbs.*	*In.*		*Lbs.*
18⅛	Small	2¼	34	Very small	14
19	Very small	2⅜	34	Small	17⅛
19⅛		2½	34½		11
21	Very small	3⅜	35⅛	Small	14⅛
22⅛	do	4¼	36	Medium	16
23		4	36⅛		16⅛
23		4¼	37	Small	14
23	Very small	4½	39	do	18
26	do	5⅜	39	Medium	21⅜
27⅛	Medium	7⅛	39½	Small	18¼
28	do	8⅛	39⅛	do	20
29		7	40	do	16
30	Very small	7½	40		17½
30		7¾	40	Medium	20⅛
30		9	40		23
30⅛		7⅛	41	Medium	23⅛
31		8⅛	41	Well developed	32
31		9⅛	41⅛	do	27
31⅛		7⅛	43		20⅛
31⅛	Small	8⅛	44	Ripe	31⅛
31⅛	Well developed	10	44½		35
32	Small	11	45	Well developed	39
33		11	48⅛	Small	31
33	Small	12	50⅛	Ripe	45½
33⅛		12	57⅛	Small	54
34	Medium	12¼			

TABLE V.—*Showing the loss in weight of cod from the round to the market-dried fish.**

Number.	Sex.	Weight, round.	Weight, split.	Weight, dried.	Weight of stomach contents.	Weight of ovaries or spermaries.	Length, round.	Length, split.	Date of capture.	Time in curing.	Percentage of loss.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*In.*	*In.*		*Days.*	
1	♀	34 1/16	18 5/16	11 5/16	1/16	4 5/16	48	30½	Jan. 29	22	.655
2	♀	23 3/16	15 3/16	10 3/16	1/16	1 2/16	41	31½	Jan. 29	22	.576
3	♀	16 5/16	10 12/16	7 5/16	Empty.	1/16	37	28¾	Jan. 29	22	.545
4	♀	12 1/16	7 11/16	4 11/16	Empty.	1/16	34½	20⅝	Jan. 29	22	.591
5	♂	7 1/16	4 7/16	3 1/16	Empty.	1/16	29⅛	23	Jan. 29	22	.585

Average loss .6023.

The loss was distributed as follows:

Loss in splitting	.4044
Loss in pickle	.1496
Loss on flakes	.0483

* These fish represent an average dryness for the year.

TABLE V (*a.*)—*Showing the loss in weight of cod from the round to the market-dried fish.**

Number.	Weight, round.	Weight, split.	Weight, dried.	Weight of ovaries or spermaries.	Weight of stomach contents.	Length, round.	Length, dried.	Time in curing.	Sex.	Percentage of loss.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	*Days.*		
1	40¾	23½	14 1/16	4	Empty ..	47	33¾	37	♀	.641
2	27⅛	14⅞	9⅛	4	..do	41¼	27½	37	♀	.67
3	18	10¼	6⅛	2	..do	37	24⅛	37	♀	.646
4	14⅛	7¾	4⅞	1⅛		35	25	37	♀	.707
5	13⅜	7⅛	4⅜	1⅛		34⅛	24	37	♀	.670
6	8¼	5	3	⅛	Empty ..	29½	21⅜	37	♀	.657
7	5½	3¼	1⅞	⅛	..do	20½	19	37	♀	.643
8	3⅛	2¼	1⅛	.....	..do	22	17	37	♀	.607

Average loss, .659.

* The fish dried as much as in the warmest weather.

TABLE VI.—*Showing the loss in weight of "George's cod" in curing, after being split and salted on the vessel.**

Number.	Length split.	Weight as they come from vessel.	Weight dried.	Percentage of loss.
	In.	*Lbs.*	*Lbs.*	
1	40	30 3/16	25 13/16	.145
2	36	21 7/16	19 7/16	.099
3	30	11	9 13/16	.119
4	30 1/2	9 1/16	8 1/16	.067
5	20	6 1/16	5 3/16	.124
6	24	5	4 1/16	.063

Average loss, .115.
*These fish represent a fair average in dryness for the winter season.

TABLE VIII.—*Showing the loss in weight of market-dried cod-fish in boning.*

Number.	Weight dried.	Weight boned.	Percentage of loss.
	Lbs.	*Lbs.*	
1	25 13/16	20 1/16	.194
2	10 1/16	8 1/16	.243
3	5 3/16	4 1/16	.234
4	3 1/16	2 1/16	.286

Average percentage of loss, .219.
One quintal of dried fish will therefore make 89 pounds of boned fish.

TABLE IX.—*Showing the loss in weight of pollock from the round to the market-dried fish.**

Number.	Weight, round.	Weight, split.	Weight, dried.	Weight of ovaries or spermaries.	Weight of stomach contents.	Length, round.	Length, dried.	Time in curing.	Sex.	Percentage of loss.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	*Days.*		
1	16 1/8	10 1/16	6 3/16	3 1/16	1/8	37	25	30	♀	.609
2	13 1/16	8 1/16	5 1/16	3	Empty..	34 1/2	23	30	♀	.569
3	12 1/16	7 1/16	5 1/16	1 1/16	...do	33 1/2	22 1/2	30	♀	.587
4	10 1/16	6 1/16	3 1/16	1/16	1 1/16	30 1/2	22	30	♀	.632
5	7 1/16	4 1/16	3	†0	1/8	26	18	30	♀	.597

Average loss, .598.
*The fish represent a fair average in dryness for the year.
† Young.

TABLE X.—*Showing the loss in weight of haddock from the round to the market-dried fish.**

Number.	Weight, round.	Weight, split.	Weight, dried.	Weight of ovaries or spermaries.	Weight of stomach contents.	Length, round.	Length, dried.	Time in curing.	Sex.	Percentage of loss.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		*Inches.*	*Inches.*	*Days.*		
1	7 1/8	4 3/4	2 5/8	1/4	Empty..	27	21 1/2	34	♀	.603
2	4 1/4	3 1/8	1 1/8	1/8	...do	25	19 3/8	34	♀	.645
3	3 1/8	2 1/8	1 1/16	1/8	...do	21 1/2	17	34	♀	.661
4	2 1/16	1 7/16	13/16	1/16	...do	18	14	34	♀	.580

Average loss, .623.

* These fish were cured as much as in the warmest weather.

TABLE XI.—*Showing the loss in weight of hake from the round to the market-dried fish.**

Number.	Weight, round.	Weight, split.	Weight, dried.	Weight of ovaries or spermaries.	Weight of stomach contents.	Length, round.	Length, dried.	Time in curing.	Sex.	Percentage of loss.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Inches.*	*Inches.*	*Days.*		
1	23 1/2	14 1/16	9 1/8	1/8	Empty..	42	32	30	♀	.582
2	12 1/8	7 3/8	5 1/8	1/8	...do	35	27 1/2	30	♀	.545
3	5 1/16	3 1/8	2 1/8	1/16	...do	27 1/2	20 3/4	30	♀	.500
4	4 1/8	3 1/16	2 1/16	1/16	...do	26	19 3/8	30	♀	.520
5	2 1/16	1 1/16	1	0	1/16	20 1/2	16	30	♀	.529

Average loss, .555.

* The fish represent a fair average for the year.

TABLE XII.—*Showing the loss in weight of cusk from the round to the market-dried fish.**

Number.	Weight, round.	Weight, split.	Weight, dried.	Weight of ovaries or spermaries.	Weight of stomach contents.	Length, round.	Length, dried.	Time in curing.	Sex.	Percentage of loss.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*		*Inches.*	*Inches.*	*Days.*		
1	17 1/8	11 1/8	8 1/16	1	Empty..	35 1/2	28	30	♀	.542
2	15 1/8	10 1/8	8	1/8	...do	33 3/4	27	30	♀	.478
3	5 1/8	3 1/8	2 1/8	1/16	...do	26	20 1/4	30	♀	.526
4	4 1/16	3 1/16	2 1/16	1/16	...do	23	18 1/2	30	♀	.440
5	3 1/16	2 1/16	1 1/16	0	...do	21	16 1/2	30	♀	.462

Average loss, .505.

* The fish represent a fair average in dryness for the year.

TABLE XIII.—*Observations on temperature at Gloucester, Mass.*

FOR THE MONTH OF OCTOBER, 1878.

Day of month.	Time of observation.				Temperature of water at surface.		Temperature of water at bottom.		Thermometer in the open air.		Winds.				State of sky.		Time of beginning and ending of rain or snow.
	First high water after 7 a.m.		First low water after 7 a.m.								High water.		Low water.				
	Hour.	A.M. or P.M.	Hour.	A.M. or P.M.	High water.	Low water.	High water.	Low water.	High water.	Low water.	Direction.	Force.	Direction.	Force.	High water.	Low water.	
	h. m.		h. m.		°	°	°	°	°	°							
18	3 40	P.M.	.....	.....	56	.....	56	.....	64	.....	SE	Light	.....	.....	Hazy	.....	
19	4 40	P.M.	11 00	A.M.	55	55	56	55	56	57	W	Strong	SW	Strong	Cloudy	Cloudy	
20	5 45	P.M.	12 00	M	53	55	54	54	53	51	W	Light	W	do	do	do	
21	6 45	P.M.	1 00	P.M.	52	53	52	53	54	57	W	Fresh	W	Light	Clear	Clear	
22	7 45	A.M.	1 30	P.M.	52	53	52	53	54	56	N	Light	E	do	do	do	
23	8 40	A.M.	2 30	P.M.	51	51	51	51	54	57	NE	Strong	E	Strong	Cloudy	Rain	Rain, 12 m. to 11 p.m.
24	9 30	A.M.	3 30	P.M.	51	50	51	51	55	57	NW	do	N	do	do	Cloudy	
25	10 25	A.M.	4 25	P.M.	49	50	50	50	53	51	NE	Fresh	NE	Light	do	do	
26	11 20	A.M.	5 20	P.M.	50	51	50	50	56	58	NE	Light	SE	do	Clear	Clear	
27	12 00	M	5 45	P.M.	51	51	51	51	55	56	SE	Strong	SE	Strong	Cloudy	Cloudy	
28	12 45	P.M.	7 00	P.M.	51	51	51	51	60	55	NW	do	NW	do	Clear	Clear	
29	1 45	P.M.	8 00	A.M.	51	50	51	50	49	46	SE	Light	NW	Light	do	do	
30	3 00	P.M.	8 50	A.M.	50	50	50	50	50	49	E	Strong	E	Strong	Cloudy	Cloudy	Rain.
31	3 45	P.M.	9 20	A.M.	50	50	50	50	52	50	SW	Light	SW	Light	do	do	Rain, 9 a.m.; light rain, 4 p.m.

FOR THE MONTH OF NOVEMBER, 1878.

1	4 45	P.M.	10 37	A.M.	50	50	50	50	43	46	NW	Strong	NW	Strong	Clear	Clear	
2	5 45	P.M.	11 45	A.M.	49	49	49	49	50	48	SW	Light	S	do	do	do	
3	6 45	P.M.	12 45	P.M.	48	48	48	48	45	46	NW	do	NW	do	do	do	
4	7 30	A.M.	1 20	P.M.	48	47	48	47	46	43	SW	do	NW	do	do	Cloudy	
5	8 15	A.M.	2 20	P.M.	46	46	46	46	32	36	NW	Strong	NW	do	do	Clear	
6	9 00	A.M.	3 00	P.M.	47	45	47	45	34	35	SW	do	W	Light	do	Cloudy	
7	9 45	A.M.	3 45	P.M.	47	45	47	46	35	36	SW	Light	SW	do	do	Clear	
8	10 15	A.M.	4 30	P.M.	45	44	45	44	37	32	NW	Strong	NW	Strong	Cloudy	Cloudy	Snow, 2 a.m. to 3.30 a.m.
9	11 00	A.M.	5 15	P.M.	43	42	43	42	36	35	NW	do	NW	Light	do	do	
10	11 30	A.M.	5 45	P.M.	44	42	44	42	41	39	NW	do	NW	do	Clear	Clear	

TABLE XIII.—*Observations on temperature at Gloucester, Mass.*—Continued.

FOR THE MONTH OF NOVEMBER, 1878.

Day of month.	Time of observation.				Temperature of water at surface.		Temperature of water at bottom.		Thermometer in the open air.		Winds.				State of sky.		Time of beginning and ending of rain or snow.
	First high water after 7 a.m.		First low water after 7 a.m.		High water.	Low water.	High water.	Low water.	High water.	Low water.	High water.		Low water.		High water.	Low water.	
	Hour.	A.M. or P.M.	Hour.	A.M. or P.M.							Direction.	Force.	Direction.	Force.			
	h. m.		h. m.		°	°	°	°	°	°							
11	12 00	M	6 15	P.M.	46	47	46	47	46	46	SW	Light	SW	Light	Cloudy	Clear	
12	12 30	P.M.	7 00	A.M.	45	45	45	45	53	49	W	Strong	SE	Strong	do	Cloudy	Rain, 5.30 a.m. to 9 a.m.
13	1 30	P.M.	7 20	A.M.	44	44	44	44	48	45	W	do	SW	do	do	do	
14	2 00	P.M.	7 50	A.M.	44	44	44	44	40	50	NW	do	NW	Light	Clear	Clear	
15	2 45	P.M.	8 40	A.M.	43	43	44	43	40	42	SE	Light	NW	do	do	do	
16	3 45	P.M.	9 45	A.M.	43	43	43	43	40	50	SE	do		Calm	Cloudy	do	
17	4 45	P.M.	10 45	A.M.	43	43	43	43	43	53	NE	do		do	do	Cloudy	Rain, 5.30 p.m.
18	5 45	P.M.	11 45	A.M.	44	43	44	43	43	46	NE	Strong	NE	Strong	do	do	Rain.
19	6 45	P.M.	12 45	P.M.	44	44	44	44	42	48	NE	Light	N.NE	do	do	do	Rain at 7 a.m.
20	7 15	A.M.	1 30	P.M.	45	44	44	44	40	43	NE	do	NE	Stormy	do	do	Rain, 11 a.m. to 5 p.m.
21	8 15	A.M.	2 30	P.M.	45	45	45	45	44	45	SW	do	SW	Calm	do	Clear	Heavy rain.
22	9 00	A.M.	3 15	P.M.	45	45	45	45	44	45	NE	Stormy	NE	Stormy	do	Cloudy	Rain, 5 a.m. to 4 p.m.
23	10 30	A.M.	4 15	P.M.	45	45	45	45	45	44	SSW	Light	W.SW	Light	do	do	
24	11 00	A.M.	4 45	P.M.	45	45	45	45	52	54	WSW	Strong	W.SW	do	Clear	do	
25	12 00	M	6 00	P.M.	45	44	45	44	45	41	WSW	Light	E.NE	do	Cloudy	do	Rain, 1.30 p.m. to 12.30 a.m.
26	12 30	P.M.	6 30	P.M.	45	44	44	44	44	45	NW	do	NW	do	Clear	Clear	Rain at 7 p.m.
27	1 45	P.M.	7 45	P.M.	44	44	44	44	50	42	ESE	do	E.NE	Stormy	do	Cloudy	Rain, 4.30 a.m.
28	2 30	P.M.	8 30	A.M.	44	44	44	44	51	46	S	Strong	S	Light	Cloudy	do	
29	3 15	P.M.	9 00	A.M.	44	44	44	44	39	63	W	Light	W.NW	Fresh	Clear	Clear	
30	4 15	P.M.	10 00	A.M.	43	43	43	43	57	65	NW	do	W.NW	do	Cloudy	do	

FOR THE MONTH OF DECEMBER, 1878.

1	5 00	P.M.	10 45	A.M.	43	43	43	43	41	54	NW	Light	NW	Light	Clear	Clear	
2	6 00	P.M.	11 45	A.M.	44	42	44	42	53	44	E	Strong	E	Strong	Cloudy	Cloudy	Rain, 1.30 p.m. to 7 p.m.
3	6 45	P.M.	12 45	P.M.	44	44	44	44	43	61	W	Light	W	do	Clear	Clear	
4	7 15	A.M.	1 15	P.M.	43	43	43	43	40	43	NE	do	NE	Light	Cloudy	Cloudy	Rain, 7 a.m. to 1.30 p.m.
5	8 15	A.M.	2 15	P.M.	44	43	43	43	43	33	W.NW	do	NW	do	do	Clear	Snow, 7.15 a.m. to 8 a.m.

6	9 00	A.M.	3 00	P.M.	42	42	42	42	30	49	W	Strong	W	do	do	do	
7	9 45	A.M.	3 45	P.M.	42	40	42	40	46	38	NW	do	NW	Strong	Clear	do	
8	10 15	A.M.	4 15	P.M.	40	39	40	39	38	41	W	Light	W	Light	do	do	Rain.
9	11 00	A.M.	5 00	P.M.	39	39	38	38	33	32	NE	do	E.SE	do	Cloudy	Cloudy	Snow, 8.30 a.m. to 7 p.m.
10	11 45	A.M.	5 45	P.M.	39	40	39	40	47	50	E.SE	do	E	Strong	do	do	Rain.
11	12 15	P.M.	6 30	P.M.	40	40	40	40	53	36	NW	Strong	NW	do	do	Clear	
12	1 00	P.M.	7 00	A.M.	41	40	41	40	44	42	W	do	W	Light	Clear	Cloudy	
13	1 45	P.M.	7 45	A.M.	41	39	43	39	47	49	NW	do	W	do	do	Clear	
14	2 15	P.M.	8 15	A.M.	42	41	42	41	49	48	NW	Light	NW	do	do	do	
15	3 15	P.M.	9 00	A.M.	39	39	39	39	49	44	W	do	SE	Strong	Cloudy	Cloudy	Snow, 4.15 a.m. to 6.30 a.m.; rain 10 a.m. to 10 p.m.
16	4 15	P.M.	10 00	A.M.	40	39	40	39	28	45	NW	do	NW	do	Clear	Clear	
17	5 15	P.M.	11 00	A.M.	38	38	38	38	32	48	NW	do	NW	do	do	do	
18	6 15	P.M.	12 00	M.	38	38	38	38	37	39	NW	do	NW	do	do	do	
19	7 15	P.M.	1 00	P.M.	38	38	39	39	27	44	NW	do	NW	do	do	do	
20	7 45	A.M.	2 00	P.M.	37	37	38	37	24	30	W	do	W	do	Cloudy	Cloudy	Rain.
21	8 45	A.M.	3 00	P.M.	36	36	36	36	45	35	SW	do	E	Light	do	do	Snow, 1.15 to 10 p.m.
22	9 45	A.M.	3 45	P.M.	37	37	37	37	51	35	SW	Strong	SW	Strong	do	do	
23	10 45	A.M.	4 45	P.M.	37	36	37	36	45	25	W	do	W.SW	Light	Clear	Clear	
24	11 45	A.M.	5 45	P.M.	36	34	36	34	34	27	SW	do	SW	Strong	do	do	
25	12 30	P.M.	6 30	P.M.	34	33	33	33	33	36	NW	do	W	Light	do	do	
26	1 30	P.M.	7 30	P.M.	33	32	33	32	30	32	SW	do	SW	do	do	do	
27	2 00	P.M.	7 45	A.M.	32	32	34	32	32	26	NE	do	N	do	Cloudy	Cloudy	
28	2 45	P.M.	8 30	A.M.	33	33	33	33	33	45	NW	Light	NW	do	Clear	Clear	
29	3 30	P.M.	9 15	A.M.	33	32	34	32	29	24	NW	do	NW	do	do	do	
30	4 15	P.M.	10 15	A.M.	33	32	34	32	30	34	NW	do	NW	do	do	Cloudy	Snow, 7 a.m. to 11.15 a.m.
31	5 00	P.M.	11 00	A.M.	32	32	32	32	33	28	W	do	W	do	do	Clear	

FOR THE MONTH OF JANUARY, 1879.

1	6 00	P.M.	12 00	M.	32	31	33	31	38	42		Calm	NW	Light	Cloudy	Clear	
2	7 00	A.M.	1 00	P.M.	32	32	32	32	35	35	NE	Light	NE	Strong	do	Cloudy	Stormy, 7.30 a.m. to 8.30 p.m.
3	7 45	A.M.	1 45	P.M.	31	33	32	33	12	20	W	Strong	W	do	do	Clear	
4	8 15	A.M.	2 30	P.M.	30	30	31	30	20	26	NW	Light	NW	do	do	Cloudy	
5	9 00	A.M.	3 00	P.M.	30	30	30	30	25	29	NW	do	W.NW	do	Clear	Clear	
6	9 45	A.M.	3 45	P.M.	30	30	30	30	24	28	NW	do	NW	Light	do	Cloudy	Snow, 12.45 a.m. to 5 p.m.
7	10 30	A.M.	4 15	P.M.	31	30	31	30	27	24	NW	Strong	NW	do	do	Clear	
8	11 15	A.M.	5 15	P.M.	31	31	31	31	35	36	SW	do	SW	Strong	do	Strong	Snow, 8.40 a.m. to 9.30 a.m.; rain, 2.30 p.m. to 3.10 p.m.
9	12 00	M.	6 00	P.M.	32	31	31	31	40	37	NE	Light	NE	Light	Cloudy	Cloudy	Snow, 3.15 a.m.—
10	12 15	P.M.	6 45	P.M.	31	31	32	31	28	27	NW	Strong	NW	do	Clear	Clear	—to 2.30 a.m.
11	1 45	P.M.	7 30	A.M.	31	30	31	31	32	21	SW	Light	SW	do	Cloudy	Cloudy	Snow, 6.15 p.m. to 8.30 p.m.
12	2 15	P.M.	8 15	A.M.	31	30	32	30	30	28	NW	do	NW	do	Clear	Clear	
13	3 00	P.M.	9 00	A.M.	33	31	33	31	35	29	SW	do	NW	do	do	Cloudy	
14	4 00	P.M.	10 00	A.M.	32	32	32	32	40	41	W	do	W	do	do	Clear	

TABLE XIII.—*Observations on temperature at Gloucester, Mass.*—Continued.

FOR THE MONTH OF JANUARY, 1879.

Day of the month.	Time of observation.				Temperature of water at surface.		Temperature of water at bottom.		Thermometer in the open air.		Winds.				State of sky.		Time of beginning and ending of rain or snow.
	First high water after 7 a. m.		First low water after 7 a. m.		High water.	Low water.	High water.	Low water.	High water.	Low water.	High water.		Low water.		High water.	Low water.	
	Hour.	A. M. or P. M.	Hour.	A. M. or P. M.							Direction.	Force.	Direction.	Force.			
	h. m.		h. m.		°	°	°	°	°	°							
15	5 00	P. M..	11 00	A. M..	30	31	32	31	13	17	NW.....	Strong....	NW.....	Strong....	Cloudy ...	Clear.....	
16	6 00	P. M..	12 00	M....	29	30	29	30	23	21	NE.....	....do.....	NE.....	....do.....	....do.....	Cloudy...	Snow, 6 a. m. to 10.30 p. m.
17	7 00	P. M..	1 00	P. M..	31	31	32	31	26	25	W.....	Light.....	NW.....	Light.....	....do....	Clear.....	
18	7 30	A. M..	2 00	P. M..	32	32	32	32	34	40	SE.....	Strong....	NW.....	Strong.....	....do.....	....do.....	Rain, 6 a. m. to 7 a. m.
19	8 45	A. M..	2 45	P. M..	31	31	32	32	23	30	NW.....	Light.....	NW.....	Light.....	Clear.....	....do.....	
20	9 45	A. M..	3 45	P. M..	31	31	32	31	24	28	NE.....	....do.....	NE.....	....do.....	Cloudy...	Cloudy...	Snow, 2 a. m. to 6.15 a. m.; snow, 10.45 a. m. to 11.15 a. m.
21	10 45	A. M..	4 45	P. M..	32	30	32	30	11	19	NW.....	Strong....	W.....	Strong....	Clear.....	... do.....	Snow, 6.45 p. m.——to 1.30 a. m.
22	11 30	A. M..	5 30	P. M..	32	31	33	31	40	33	SW.....	Light.....	N.....	Light.....	....do.....	....do.....	
23	12 00	M....	6 00	P. M..	31	31	31	31	43	40	NW.....	....do.....	N.....	Strong....	Cloudy ...	....do.....	Rain, 11.30 a. m. to 12.30 p. m.
24	1 00	P. M..	7 00	P. M..	31	32	32	32	31	32	SW.....	Strong....	SW.....	....do.....	Clear.....	Clear.....	Snow squall, 11.15 p. m.
25	1 30	P. M..	7 30	A. M..	32	32	32	32	39	53	SW.....	Light.....	SW.....	Light.....	....do.....	....do.....	Snow squall, 9.30 p. m.
26	2 00	P. M..	8 00	A. M..	31	31	33	31	20	10	NW.....	Strong....	NW.....	Strong.....	....do.....	....do.....	
27	3 00	P. M..	8 45	A. M..	33	30	33	30	33	20	S.....	....do.....	SE.....	....do.....	Cloudy...	Cloudy...	Rain, 2.30 p. m. to 3.30 p. m.; 6 p. m. to 9.45 p. m.
28	3 30	P. M..	9.30	A. M..	33	32	33	32	44	33	SE.....	Light.....	SE.....	Light.....	....do.....	....do.....	Rain, 5 a. m. to 7 a. m.