

XIII.—THE SPANISH MACKEREL, *CYBIUM MACULATUM* (MITCH.). AG.; ITS NATURAL HISTORY AND ARTIFICIAL PROPAGATION, WITH AN ACCOUNT OF THE ORIGIN AND DEVELOPMENT OF THE FISHERY.

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A.—NATURAL HISTORY

1.—THE COMMON NAME.

The term Spanish mackerel is by no means an uncommon one. It has long been and is still applied to one or more species of fishes in nearly all countries where the English language is extensively spoken. As nearly as can be ascertained, it was first applied to the *Scomber colias* of Europe by the British fishermen, on account of the peculiar

abundance of the species on the coast of Spain. The name was introduced into the United States by the early English colonists, who, on reaching America found a great variety of fishes in the waters of the newly-discovered continent. Some of the species were entirely new to them, while others resembled to a greater or less extent the species with which they were familiar in their early homes. To all of these fish they must assign names, and it was very natural for the colonists to apply to them the names of the European species which they most nearly resembled.

Those settling on the New England coast found a species of mackerel which was very similar in its general appearance to the *Scomber colias*, and they at once gave to it the name Spanish mackerel, supposing it to be the common English species. In fact, so close was the resemblance that, until recently, most naturalists have considered the two species identical, though they are now generally acknowledged to be distinct. The colonists settling in the Middle and Southern States, where the species already mentioned was not found, applied the term Spanish mackerel to the *Cybium maculatum*; and it has, by many, been commonly applied to the other members of the genus, namely, the *C. regale* and the *C. cabella*.

The name, however, does not properly belong to either of the last-named fishes, for the adults of these species are usually known as "cero," "king-fish," or "horse-mackerel," though in localities where the *C. maculatum* is taken the fishermen apply the term alike to all small fishes of the genus, few, if any, owing to the marked similarity in their general appearance, recognizing the difference between them. Even here, however, the difference is recognized in the larger individuals, and the name is changed accordingly.

The Northern species continued to be abundant along the New England coast up to 1855, when it entirely disappeared from our shores, and not a single individual is known to have been taken from that date until the summer of 1879, when the United States Fish Commission secured several specimens off Provincetown, Mass.* Since the disappearance of the New England species the *Cybium maculatum* has practically enjoyed

* We find the following in the Fisherman's Memorial and Record Book, which gives an idea of the abundance of the species in Massachusetts Bay in the early part of the present century:

"In 1812 a large school of Spanish mackerel visited this bay, and so plenty and numerous were they that they would bite readily at the bare hook, and seize upon small bits of line hanging from the vessel. Standing-room boats were then mostly in use, holding from 15 to 20 tons. These rooms held from 15 to 20 barrels, and the crews would catch them full in a few hours. Mr. Timothy Rogers, at Rowe's Bank [at Gloucester, Mass.], bought most of these mackerel fresh, after being dressed, at 2 cents per pound, salting them in his buildings, and the business, which lasted two months, was a lively one. These mackerel did not continue on this coast but a few years, and have now almost entirely disappeared. There were a few caught with the other mackerel as late as 1825, since which time it is very rare to see one during the entire season."—(Fisherman's Memorial and Record Book, p. 61.)

a monopoly of the name within the limits of the United States. But though this is the only species to which the name Spanish mackerel properly belongs, it must not be inferred that the fish is always called by its right name. On the contrary, the fishermen have several names for it. In the Gulf of Mexico and along the Southern Atlantic coast it is universally known as the "Spanish mackerel." About Wilmington, N. C., it is occasionally taken by the fishermen, some of whom call it by its proper name, while others know it as the "horse-mackerel". In Chesapeake Bay it is called "bay mackerel", or, almost as frequently, simply "mackerel". On the New Jersey coast it is frequently called the "spotted mackerel" to distinguish it from the *Scomber scombrus*, which is known as the "mackerel" or "banded mackerel". Again, Josselyn, who visited the New England coast in the early part of the sixteenth century, spoke of the "speckled hound-fish" in such a way that Professor Goode thinks he could have referred to no other species than our *Cybium maculatum*. DeKay described it as the "spotted cybium"

2.—DESCRIPTION OF THE SPECIES.

Six species of the genus *Cybium* are found in American waters, but thus far only three of them have been taken within the limits of the United States, the others occurring about the West Indies. The species frequenting our coast, namely, *C. maculatum*, *C. regale*, and *C. cabella*, have already been mentioned. These are very similar in general appearance, and were it not for the difference in size, few fishermen would recognize them as distinct species.

The *Cybium maculatum*, the species at present under consideration (see Plate I) was first described by Mitchill, under the name of *Scomber maculatus*. Later, Agassiz referred it to the genus *Cybium*, calling it the *Cybium maculatum*, a name that is now universally adopted. The species is similar in form to the common mackerel, though in size and color it is quite different. It is, without question, one of the most beautiful fishes of our coast, and few of the fishes of the tropical seas surpass it in brilliancy. Its back has a greenish tint, which gradually shades into leaden or dove color on the sides. All of the under parts, including the lower sides, gill-covers, and ventral and anal fins, are pearly white. About twenty yellowish spots, varying from one-eighth to one-third of an inch in diameter, and forming a brilliant contrast with the leaden background, are scattered irregularly along the upper sides, chiefly on the anterior portion of the body. A prominent lateral line begins just above the operculum, rising slightly at first, then bending downward and continuing in a crooked or wavy path almost to the tail. The head is long and pointed, the eyes large and yellowish, with double nostrils situated slightly in front of them. The mouth is very large and the powerful jaws are armed with strong, slightly compressed, or nearly conical teeth, except in their anterior portion, where these are rudimentary or even entirely wanting. The spinous dorsal has a black marking on

the upper anterior margin, the remainder being pure white. The soft dorsal, like the dorsal finlets, which are eight in number, is slightly brownish. The somewhat acuminate pectorals are brown on the outer surface, and darker within. The ventrals are quite small, while the tail is peculiarly large and broadly forked, the extremities being several inches apart. The radial formula is Br. 5; D. 17-16; A. 18; P. 20; C. 24; V. 4.

The other species of the genus, though much less abundant, resemble very closely the one already described. *C. regale*, the king-fish of our southern coast, like the Spanish mackerel, has 17 spinous rays in the dorsal, and also similar black markings, but it is distinguished by longitudinal bands of gold along the sides. It often attains a length of 4 to 6 feet, and a weight of 15 or even 20 pounds. The *Cybium caballa* readily distinguished by the absence of black markings on the first dorsal, as well as by its fewer rays, these being only 14 in number. The young of the species has indistinct circular markings, which entirely disappear with age.

Spanish mackerel vary somewhat in size, according to the locality, the largest individuals, as a rule, being found farthest north or at a considerable distance from the shore. The largest specimens of which we have any record weigh about seven pounds. The majority of those seen in the markets weigh between 1½ and 3 pounds, and their average length is from 17 to 22 inches. Those taken in the pounds-nets at Mobjack Bay, on the western shores of the Chesapeake, do not exceed 1½ pounds in weight, while on the eastern shore, directly opposite, they are somewhat larger. Those taken at Crisfield, Md., in gill-nets, average about 2 pounds. Off Sandy Hook, N. J., they are larger still, the size apparently increasing as we proceed seaward, the largest individuals being taken 10 to 15 miles from land. The gill-net catch averages 3½ pounds to the fish, but the average for those taken in the pounds along the beach is only 2¾ pounds.

3.—GEOGRAPHICAL DISTRIBUTION.

The geographical distribution of the Spanish mackerel is still unsettled. Along our own shores it is chiefly confined to the coastal waters, and is less abundant in the open ocean, apparently preferring the shoal soundings, where its food occurs in greater quantities. It, however, pursues its prey to a considerable distance from land, and is often seen 40 to 50 miles to seaward.

The southern limit of the species has not yet been determined, and many claim that its northern range has been greatly extended within the last few years. Professor Goode, in writing of the species, says: "Spanish mackerel visit the north as marauders. Their home is among the reefs of the Gulf of Mexico and the Caribbean Sea, and they come to us only to feed on the small fishes which frequent our waters in immense schools." He gives their northern limit as Cape Cod, adding

that stray individuals have been found on the coast of Maine. Narragansett Bay is, however, the most northern point where they occur in sufficient numbers to warrant a special fishery. Farther south, especially off Sandy Hook, N. J., they are more abundant. They enter Chesapeake Bay in great numbers, and quantities of them are secured by the fishermen. According to Mr. Thaddeus Norris, they occur in considerable numbers in the Gulf of Mexico, and are quite abundant along the Florida coast; many being shipped from Cedar Keys to Savannah and other Southern cities.

4.—MOVEMENTS.

Spanish mackerel are gregarious in their habits. They are sometimes seen in enormous schools, covering several square miles of ocean surface. A single school seen off Long Island a few years ago was estimated to contain several million individuals. The density of these schools, however, is very different from that of the schools of menhaden, on which they feed. The latter are usually found in compact masses, often many feet in thickness; while the former are considerably scattered, a large percentage of them being at or near the surface of the water.

The fish make annual excursions to the coast of the United States in summer; starting from their home in the warmer waters of the South, or, perhaps, from the deeper waters along the inner edge of the Gulf Stream, in the early spring, and proceeding northward, or landward, as the season advances. After remaining for a few weeks, or months at most, they again move southward, or seaward, and at the approach of cold weather entirely disappear. They seem to prefer water ranging from 70° to 80° Fahr., and seldom enter that which is colder than 65°.

Off Charleston, S. C., the fish are first seen about the last of March, and late in April they enter the sounds of the North Carolina coast. By the 20th of May the vanguard reaches the Chesapeake, and others follow in rapid succession, so that by the middle of June the capture of mackerel constitutes the principal occupation of the fishermen. Off Sandy Hook they are seldom seen till late in July,† though from that time they continually increase in numbers till the middle, or even the last, of August. Their time of arrival at Narragansett Bay is about the same as that for the New Jersey coast. In this northern region they remain till the middle of September, after which the number grad-

* The Canadian fishery report for 1880 contains the following notice of the capture of a Spanish mackerel at Prince Edward's Island, in the Gulf of Saint Lawrence, which (if there is no mistake in the identification) extends by several hundred miles the range of the species. The report says: "An undoubted specimen of the Spanish mackerel, male, *Cybium maculatum*, of the United States, was caught by hook at New London, Queen's County, on the 7th of September. It is rare to find this fish in so high a latitude."—(Supplement No. 2 to the Eleventh Annual Report of the Minister of Marine and Fisheries for the year 1880, p. 229.)

† Mr. Scott states that the young of the species are sometimes taken off the Long Island coast in June.

ually diminishes, and by the 1st of October the last individuals have disappeared. A little later they leave the Chesapeake, and few are seen on the Carolina coast after the 1st of November.

Their summer movements are doubtless affected to a considerable extent by the movements of the menhaden and other small fishes on which they feed, as they are usually most plenty in the localities where these fish are found. They exhibit great activity in the capture of their prey, darting through the water with great speed, and often leaping into the air in long and graceful curves, cutting the water neatly as they re-enter it. This peculiar leap is characteristic of the species, and by it the fishermen are enabled to distinguish the mackerel from their allies, the blue-fish, that after jumping from the water fall back upon its surface with a splash.

During the spawning season the mackerel enter the warmer and shoaler water of the bays, the individuals at this time being quite generally distributed and the schools often considerably scattered. On entering the Chesapeake, they remain about "The Capes" for some time, but as the season advances, according to Mr. Sterling, of Crisfield, Md., they start for the upper waters, and distribute themselves over the large spawning grounds of the region. Some weeks later they reassemble, and proceed down and out of the bay on the way to their winter quarters.

In moving along the coast the mackerel seem to avoid fresh or even brackish water, and for this reason are seldom taken near the mouth of the larger rivers. This habit is thought to account for their greater abundance on the eastern than on the western side of the Chesapeake. Along the last-named shore the saltness of the water is considerably affected by the enormous quantity of fresh water brought down by the large rivers of the State; no rivers of importance occur along the eastern shore, and this portion of the bay is, therefore, nearly as salt as the ocean.

During its stay on our coast, the Spanish mackerel may properly be styled a surface fish. It seldom descends to any great depth, but rather remains at or near the surface, and may often be seen leaping into the air or sporting at the top of the water. On a calm, bright day the surface of the ocean is sometimes broken for miles together by the movements of a large school of these fish.

5.—ABUNDANCE, PAST AND PRESENT.

There are many and conflicting opinions with reference to the first appearance of the Spanish mackerel in our waters. Many sportsmen, whose opinions should be entitled to some weight, agree with the majority of the marketmen and fishermen in saying that the species was seldom seen prior to 1850, and that it did not become an important food-fish till some years later. Others, who have studied the movements of the species more carefully, claim, and with reason, that it has visited the coast of the United States each summer since the earliest settlement of

the country. Professor Goode, in his *Game Fishes of the United States*, says: "The early chronicles of the colonists contain no references to the Spanish Mackerel under its present name; but it seems quite probable that this fish was the Speckled Hound-fish spoken of in that renowned work, 'New England's Rarities discovered in Birds, Beasts, Fishes, Serpents, and Plants, of that Country, etc. By John Josselyn, Gent.,' published in 1672. Josselyn wrote of 'blew-fish or hound-fish, two kinds, speckled hound-fish and blew hound-fish, called horsefish.' The Blue Hound-fish can be nothing else than the common Bluefish of our coast, *Pomatomus saltatrix*, and no species in the Western Atlantic, other than our Spanish Mackerel, resembles the Bluefish closely enough to warrant the use of a similar name." If this supposition be correct, the Spanish mackerel was very abundant during the seventeenth century. But the species must certainly have decreased greatly in numbers after that date, especially along the New England coast, for though it was not entirely absent, as shown by the fact that reference is made to it by various ichthyologists from time to time, yet it was not sufficiently abundant to be generally known to the fishermen of the country, or to be sent in any quantities to the principal markets. Mr. Scott, in writing of the species, in 1875, says it "is a comparative stranger to us, and though never known to venture as far north as the fortieth degree of latitude until about ten years since, yet his families are now as numerous on our coast as are those of most other estuary fishes."

The date of its first appearance in the New York market could not have been far from 1840; and as late as 1854 Professor Gill reported the species as having very little commercial importance.

Prior to 1850 almost nothing was known of the fish about Sandy Hook. About this time, Mr. Robert Lloyd, a fisherman of Seabright, while engaged in trolling for blue-fish, secured quite a number of Spanish mackerel, these being the first he had ever seen. He carried them with the blue-fish to one of the hotels, the proprietor of which had entered into an agreement with him to take his entire catch; but that gentleman, knowing nothing of the mackerel, refused to buy them at any price.

From this date they were taken more frequently, and soon came to be highly prized as an article of food. They were caught wholly by trolling, the average daily catch being from ten to twenty fish to the boat; the fishing being best when the water was a little rough. Later they continued to increase in number, or at least came to be more generally noticed by the fishermen, until 1866, when it is said they were often nearly as plenty as the blue-fish, though comparatively few were taken, owing to the lack of suitable apparatus, and it was not until the introduction of properly arranged gill-nets and pound-nets that the fishermen were successful in securing any considerable quantities.

Since 1875 it is claimed that their numbers have gradually decreased on the inshore grounds, though they are said to be as numerous as for-

merly 8 to 10 miles from land, where they remain beyond the reach of gill-nets and pounds.

Many of the fishermen of Chesapeake Bay never saw the species prior to 1875, though there are authentic records showing that individuals were occasionally taken in the haul-seines along the Eastern Shore as early as 1860, and hauls of between one and two hundred are reported by Dr. J. T. Wilkins in 1866. It is, however, very easy to explain the ignorance of the fishermen as to the abundance of the species in that region, for, until recently, the fisheries of the Chesapeake appear to have been of small commercial importance, having been prosecuted only during the spring and fall by means of gill-nets and haul-seines. During the summer months, when the mackerel are most plenty, no fishing of importance was done. Pound-nets were introduced into the Chesapeake region in 1875, and it was through their use that the fishermen came to know of the abundance of the species in these waters.

On the North Carolina coast most of the fishermen, and, indeed, a majority of the dealers, are still unacquainted with either the name or the value of the mackerel, and when, in 1879, several thousand pounds of them were brought to Wilmington the dealers refused to buy them, supposing them to be a species of horse-mackerel (*Orcynus*), which they understood had no value as a food-fish. As no purchasers could be found for them they were finally thrown away. Farther south few have been taken, owing to the lack of suitable apparatus as well as to the fact that the fishermen seldom fish beyond the inlets. The smack fishermen of Charleston catch a few on troll-lines during the pleasant weather of the spring and early summer, but they fish only occasionally in this way.

Though the fishing is at present limited to certain localities, there is no reason to believe that the fish are absent from other places; on the contrary, it seems probable that, should proper apparatus be employed, the species could be taken at almost any point along the outer shore where the menhaden are abundant.

In the Chesapeake region there seems to be no diminution in the catch; on the contrary, it has increased rapidly from year to year, until in 1879 it amounted to fully 1,000,000 pounds, and in 1880 the quantity was increased to 1,609,663 pounds. The average daily catch for the pound-nets about Cherrystone, Va., is fully 500 fish; while as many as 4,000 have been taken at a single "lift", and hauls of 2,500 are not uncommon during the height of the season. At Sandy Hook the catch is quite large; in 1879, 3,500 pounds were taken at one haul in a pound-net at Seabright, and the average stock for the pound-nets in that locality often exceeds \$1,000 for mackerel alone, while the catch of other species is proportionately large.

We see no reason for believing that the present enormous catch will have any serious effect upon the future abundance of the species; for, assuming that the fish are plenty all along the coast, the catch, though extensive at certain points, must be insignificant in comparison with the

immense number of individuals in the water. As has been shown, however, there is good reason for believing that the quantity has varied from time to time in the past, and it may be that natural causes, of which we are still ignorant, and over which we have no control, may cause a like variation in the future.

6.—FOOD.

No careful examination has yet been made of the stomach contents of the Spanish mackerel, and little is known of his food, beyond the knowledge of its habit of feeding upon various small fishes, chief among which are menhaden and alewives, of which it consumes enormous quantities. It is an exceedingly voracious fish, its powerful jaws, armed with strong teeth, being peculiarly adapted to cutting and tearing its prey; and, like the blue-fish, it often mutilates its victims, biting only a small portion from the body, and leaving the remainder to be eaten by other fishes that follow in its wake. It seems probable that its food consists almost exclusively of these small fishes, and that it seldom, if ever, preys upon the invertebrates of the bottom, as it is in no sense a "bottom feeder." In speaking of the food of the mackerel, Mr. Scott says: "These fish surround a shoal of gar-eels, butter-fish, shiners, spearing or young menhaden, when the tiny bait—anxious to escape—rise to the surface, followed by the Spanish mackerel, which may be seen two miles distant, leaping, a thousand at a time, their forked tails conspicuous, and their bodies gleaming like miniature rainbows."*

7.—REPRODUCTION.

Prior to 1880 nothing was definitely known regarding the spawning habits of the Spanish mackerel. Neither the time nor place of spawning had been discovered. Mr. Scott had surmised that they spawned in the waters of our Atlantic States in the spring, as small ones which he supposed to be the young of the previous year were occasionally seen in June.† Prof. Goode, in his *Game Fishes*, had ventured the assertion that they probably spawned in mid-winter, in the Gulf of Mexico and about the West Indies. These were, as far we know, the only writers that had referred to the spawning habits of the mackerel. During an extended tour of the Atlantic coast, in company with Col. Marshall McDonald, the writer had an excellent opportunity for examining the species in different localities, and succeeded in proving that the theory advanced by Mr. Scott was the more nearly correct, and that the Spanish mackerel spawn along many portions of the Atlantic coast

* Fishing in American Waters, by Genio C. Scott, 1875, p. 129.

† The following is the language of Mr. Scott on this point: "Both the Spanish mackerel and cero are spring-spawning fishes, and no doubt spawn in our bays, for there are occasionally small ones taken by the anglers in June, before the large ones visit our shores, and I argue, therefore, that the small half-pounders are of last year's hatch."—*Ibid.*, p. 129.

in mid-summer. The investigation of the Southern fisheries began in Florida in January, 1880, and when the fishery interests of that state had been sufficiently studied, we proceeded northward, visiting every important fishing station along the coast of Georgia and the Carolinas, reaching the Chesapeake early in May. After spending some time at Norfolk, and at the fishing shore of Capt. W. E. Taylor, at Willoughby, we accepted the invitation of Mr. O. E. Maltby to visit his fishing station at New Point, 40 miles up the bay. Here we spent a number of days in examining the spawning condition of the different species taken in the pound-nets of the locality, and soon discovered that many of the male mackerel were nearly ripe, while the eggs in the ovaries of some of the females were well developed. A little later we succeeded in finding thoroughly ripe males and one or two females from which ripe eggs could be taken. Appreciating the importance of this discovery, we continued our investigation, and soon satisfied ourselves that the spawning time was near at hand, as the eggs and milt in all of the specimens examined were well advanced. Later, the writer visited the Eastern Shore of Virginia, including the counties of Accomack and Northampton, and found ripe eggs and milt in a large number of individuals. Further investigation proved that the spawning season, as in many migratory species, varies with the locality, being earliest on the Southern coast, and latest about Long Island. The temperature of the water seems to have a decided effect upon the spawning time of the mackerel, and the ovaries and spermaries do not develop very rapidly until it has risen to upwards of 72° Fahrenheit. The time of spawning for the Carolinas begins in April, while the season at Long Island commences by the 20th of August, and continues till the latter part of September. On the arrival of the species in the Chesapeake, in May, a few of the males are nearly ripe, and the ovaries of the females are very much enlarged. By the 1st of June occasional ripe fish are seen. The spawning season proper begins about two weeks later, and continues during the greater part of the summer. The fishermen report many of the mackerel to be full-roed when they reach the Sandy Hook region, and claim that by the last of August the eggs begin to separate and run from the female. From this date to the close of the season numerous individuals are taken from which eggs or milt will run freely.

The limits of the spawning grounds have not yet been definitely ascertained, though enough has been learned to show that the mackerel spawn at numerous points between Narragansett Bay and South Carolina, and it seems probable that when a thorough investigation is made the southern limits will be found to extend as far as Mississippi and perhaps to Texas. It is certain that they spawn in some of the sounds of the Carolinas, in Chesapeake Bay, off Sandy Hook, and along the southern shores of Long Island; the Chesapeake and Sandy Hook regions being visited by immense numbers of mackerel for this purpose.

As has been said, the spawning season for our coast continues throughout the entire summer, and, in any particular locality, it lasts from six to upwards of ten weeks. The time of spawning for individuals of the same school varies considerably, the ovaries of some of the fish being fully mature while those of others are still quite green. Again, a single individual is a number of weeks in depositing its eggs, as shown by the fact that when the first are excluded a large percentage are still small and immature. All of the eggs in the ovaries of a shad, salmon, or white-fish develop uniformly, and the whole number are deposited at about the same time, so that the spawning season for the individual lasts only a few days at most. Up to the winter of 1878-'79 it had been supposed that all fishes were alike in this particular; but our study of the cod at that time proved that the individuals of that species were several months in depositing their eggs, and the same is found to be true, within smaller limits, of the Spanish mackerel.

The number of eggs varies with the size of the parent fish, that for a one-pound mackerel being estimated at 300,000, while that for a six-pound fish can scarcely be less than 1,500,000. To ascertain definitely the number for the average fish, an immature female, weighing one pound and thirteen ounces, and measuring $18\frac{1}{2}$ inches was selected, and the number of eggs was carefully computed. The ovaries, when placed on accurately adjusted balances, were found to weigh 34.275 grams. These were then opened, and a 100 milligrams, selected from different portions of the roe-bags, so that all sizes might be represented, were weighed out. When counted this mass was found to contain 1,536 eggs. From these data it was found that the ovaries of the fish should contain 526,464 eggs. This number would be too great, as no allowance was made for the weight of the ovary walls; allowing for these, the number would be not far from 525,000. It is thus seen that the species is more prolific than the salmon, shad, or white-fish, though it is much less so than many of the gadoids, a 75-pound codfish yielding fully nine millions.

The eggs of the Spanish mackerel are smaller than those of any other species with which we are familiar. During the early part of the season they can scarcely be distinguished by the unaided eye, and although they gradually increase in size, when fully ripe they have a diameter,—varying somewhat with the size of the parent and the condition of the eggs when pressed from the ovaries—of only one twenty-second to one twenty-eighth of an inch. Most of those secured by us were of the last-named size, and taking these as a basis it will be seen that a cubic inch would contain 21,952 eggs, and that 1,267,728 could be placed in a quart cup.

After impregnation the eggs have a specific gravity between that of fresh and salt water, as shown by the fact that they sink in one and float in the other. When thrown from the parent they rise to the surface, and are driven hither and thither by the winds and tides during the earlier period of development. Many are lost from lack of fertiliza-

tion, others are destroyed by the animals of the water, and considerable quantities are doubtless driven upon the shore during stormy weather, where they soon perish.

When first hatched the little mackerel is quite transparent, its length scarcely exceeding one-tenth of an inch, while its diameter even with the comparatively large yelk-sac is so small as to allow it to pass through wire cloth having 32 wires to the inch. For several hours after hatching it remains comparatively quiet at the surface in an almost helpless condition, a small oil globule attached to the yelk-sac keeping it from sinking and causing it to lie belly upper-most. Later the umbilical sac with its oil globule is gradually absorbed, and the little fish begins to manifest greater activity, and by vigorous and spasmodic efforts penetrates to the depth of an inch or so below the surface. In a few hours it finds little or no difficulty in swimming at various depths and even lies at the bottom of the vessel in which it is confined, darting off with surprising rapidity when disturbed.

So far nothing is known of the rate of growth. We know of but two instances where small mackerel have been caught or even seen along our shores. The first is that mentioned by Mr. Scott, in the passage already quoted, of half pound fish having been taken off the Long Island coast in June. A second instance was made known to us by Mr. Robert Bosman, superintendent of a fishing station at New Point, Va., who, in a letter dated Norfolk, Va., September 25, 1880, says: "I have recently noticed large numbers of young Spanish mackerel, varying from four to six inches in length." Assuming that the fish referred to were the young of the Spanish mackerel, there still remains a difficulty in determining the rate of growth. Some species grow very rapidly, reaching the last-named dimensions in a few months, while others develop more slowly and would not attain a weight of half a pound for several years. From our limited knowledge of the growth of other species we would suppose that the fish mentioned by Mr. Bosman as being 4 to 6 inches long in September were the fry of the previous year, and were therefore about fourteen months old, while the half-pounders mentioned by Mr. Scott were probably nearly two years old.

B.—ORIGIN AND DEVELOPMENT OF THE FISHERY.

8.—THE FISHING GROUNDS:

Spanish mackerel may be taken with trolling hooks along almost any portion of the coast between Key West and Long Island; but as this method of fishing is practically restricted to a few localities the troll-line catch is quite unimportant. Enough are caught, however, to show that the species occurs, and to indicate that the fishing grounds may be considerably extended in the future.

Professor Goode states, upon the authority of Thaddens Norris, that in the Gulf of Mexico they are sometimes taken by means of hook and

line with shrimp bait, at the ends of the long piers where the steamboats land in going from Mobile to New Orleans, and that they are so abundant on the Gulf coast of Florida, as to be shipped in considerable numbers from Cedar Keys. Since the statement by Mr. Norris, a careful study of the fisheries of the Gulf has been made by Mr. Silas Stearns, of Pensacola, Fla., under the direction of the United States Fish Commission and the Census Office. The reports forwarded by him lead us to believe that, whatever may have been the catch of the past, that of 1880 was so small as to be of little commercial importance, though this is perhaps due to a lack of suitable apparatus of capture rather than to any scarcity of the mackerel.

Off the east coast of Florida a few are landed by a smack fishing for the Savannah market. Off Charleston small numbers are secured by the crews of the vessels employed in the blackfish fishery, who claim to see occasional schools of mackerel, and think that in case they should make a practice of fishing for them considerable quantities could be secured.

On the North Carolina coast there are no summer vessel fisheries, and but few boats fish along the outer shore, none using methods suited to catching the mackerel. Parties fishing with seines along the inner bays caught few of these fish prior to 1879. During this season they are said to have been quite plenty for a short time, and many were taken by the fishermen, who, being unacquainted with the species, did not recognize its value, and, instead of saving their mackerel, threw the greater part of them away. Some, however, were taken to Wilmington, but, as has already been stated, the dealers refused to purchase them, thinking them to be a species of horse-mackerel, which they supposed to be of little value for food.

Chesapeake Bay has by far the most extensive fishery for Spanish mackerel in the United States; the other fisheries, in order of importance, being those of Sandy Hook, Southern Long Island, and Narragansett Bay. Few are taken on the southern coast of New Jersey, as little fishing is done along the outer shore. Some are, however, secured by the vessels trolling in the vicinity of Barnegat Inlet, and the menhaden fishermen of Tuckerton occasionally catch them in their purse-seines.

The commercial fishery is of recent origin, and it is only within the past few years that any considerable quantities have been taken for market. The fishery practically began off the New Jersey coast in 1873, and the mackerel were first extensively taken in Chesapeake Bay in 1875. This fact has little or no significance in its bearing upon the abundance of the fish, for the increased catch is almost wholly accounted for in both localities by the change in the methods of fishing.

9.—APPARATUS AND METHODS OF CAPTURE.

Three kinds of apparatus are used in the Spanish mackerel fishery, namely, the trolling-line, the gill-net, and the pound-net. The trolling-

line is more extensively employed off the Long Island coast and along the shores of Northern New Jersey than in any other locality. It was introduced into the region at an early date, and for some time was the most important method in the fishery. It has been less extensively used during the past ten years, and is now chiefly employed by parties fishing several miles from the shore. Large open boats and small sloops carrying from two to five men each are used for trolling. The trolling-hooks, or "squids," as they are frequently called, differ greatly. Some are made of bright metals in the form of a fish, while others more nearly resemble the body of a squid, these being usually painted in brilliant colors. The number of hooks varies from one to three, according to circumstances. In the absence of manufactured squids, the fishermen frequently improvise very good ones by attaching pieces of red or white cloth to ordinary fish-hooks. In fishing, the hooks are attached to lines several fathoms in length, four or five of these being towed behind the boat, which spreads enough canvas to drag them through the water at a speed of two to four miles per hour. The fishermen are often successful in catching large numbers of mackerel in this way.

At Sandy Hook gill-nets were first employed in the capture of mackerel in 1866, but being "set taut," they were not very successful, the fish usually detecting their presence and refusing to enter them. When it was found that, although abundant, the fish did not gill readily, schools were often surrounded by the nets, after which the fishermen attempted to frighten them into the meshes by splashing with oars in the center of the circle. The majority, however, would pass under the lead-lines, or jump over the cork-lines, and escape, so that comparatively few were taken. Still the nets continued to be used with varying success, though the bulk of the catch was taken by trolling. About 1872 or 1873 it was accidentally discovered that the mackerel would gill more readily in nets set in such a way as to present sharp angles, quite a number having been secured in a net that had become twisted and tangled by the currents. This fact suggested a change in the manner of setting, and various experiments were made by the fishermen of Seabright with good results. The first "sets" were somewhat crude, but experience enabled the fishermen to improve upon them from year to year.

The figures in Plate II represent the principal methods of setting the gill-nets for the capture of Spanish mackerel off Sandy Hook from 1866 to the present time. Figure 1 shows the first method, locally known as the "straight-set." The other figures represent, in their order, the more important methods that have since been introduced. At the present time the three sets shown in Figures 6, 7, and 8 are commonly employed. These are locally known as the "square-set," "T-set," and "harpoon-set," the names describing, to a certain extent, the shape of the nets as they appear in the water. In the square-set, Figure 6, two nets are employed, one being placed perpendicular to the shore to form a

leader, while the other is set in the form of a square at the outer end, openings of three or four feet being left on either side of the leader to allow the fish to enter. The T-set, shown in Figure 7, somewhat resembles the one already described, the chief difference being that the ends of the outer net, instead of being bent at right angles, are turned inward to form a triangle at the outer extremity of the leader. In the third set, Figure 8, the two nets are so arranged as to form a harpoon, from which the set takes its name.

The gill-nets of this region are worth from \$90 to \$100 apiece. They are about one hundred fathoms long and one hundred meshes deep, the size of the mesh varying from $3\frac{1}{2}$ to 4 inches. The men fish in "gangs," one net being owned by the crew of each boat. The nets are set on the best fishing grounds at daybreak, and are left for several hours, while their owners fish with hand-lines in the vicinity. The catch is divided equally, the share for a single net being sometimes as high as five hundred dollars for a season which lasts from six weeks to two months.

Gill-nets were introduced into the Spanish mackerel fisheries of Chesapeake Bay in 1877, and proving fairly successful, they soon came into general favor among the fishermen of the Eastern Shore, though they are even now seldom employed by those living on the opposite side. There are, at present, about 175 men engaged in "gilling" for mackerel between Crisfield, Md., and Occoanock Creek, which is 30 or 40 miles from the capes. The nets were at first set only in the night, but during 1880 the fishermen of Tangier Island obtained the best results by fishing from the middle of the afternoon until midnight. The nets range from 75 to 100 fathoms in length, and have a similar mesh to those already mentioned. The catch varies considerably, as many as 500 mackerel having been taken at one set, though the average is only 20 to 40 daily to the net.

The pound-net is now the principal apparatus for the capture of mackerel in all localities where the fishery is extensively prosecuted. According to Mr. R. B. Chalker, of Saybrook, Conn., pound-nets were first used in the fisheries of New England at Westbrook, Conn., in 1849, and from that locality they spread rapidly to other portions of the coast. They were first introduced at Sandy Hook, N. J., by Mr. George Snediker, of Gravesend, Long Island, about 1855. Mr. Snediker has probably done more to develop the pound-net fisheries of the United States than any other man in the country. It was from him that the fishermen of New Jersey, as well as those of Chesapeake and Delaware Bays, obtained their first idea of pound-nets, he being the first to introduce them unto the fisheries of each of these regions. He has also engaged in the pound-net fisheries of Albemarle Sound, though he cannot claim the credit of introducing the net into those waters.

The first pounds fished in New Jersey were very small, and being placed along the inner shore of Sandy Hook, they were hardly a success, as the fish are much less abundant there than along the outer shore. The same

style of pounds were, however, fished with varying success until about 1873, when larger ones were placed along the ocean shore; and then, for the first time, their importance in connection with the Spanish mackerel fishery was discovered. The majority of the mackerel secured about Sandy Hook are now taken in this way. One hundred fish in number was considered an average daily catch for the fishing season of 1879, and 100 to 140 for 1880, though much larger catches were occasionally secured. The best day's fishing for a pound-net in that locality occurred in the summer of 1879, when Mr. Robert Potter took 3,500 pounds, valued at \$700, at a single lift.

An effort was made as early as 1858 by Capt. Henry Fitz Gerald to introduce the pound-net into the waters of Chesapeake Bay, but his net was not properly constructed, and was so unsuccessful that it was soon taken up. No other attempt was made to fish with pound-nets in this region until about 1870, when Mr. Snediker and Charles Doughty, of Fairhaven, N. J., came to Virginia and located on the banks of James River, a few miles above its mouth. They fished chiefly for shad and alewives, continuing their work for about three years, after which they disposed of their property and returned to the North. In 1875 Mr. Snediker again visited the Chesapeake, located at New Point, Va., where he built a large pound in the waters of Mobjack Bay for the capture of shad and other species. The fishermen of the neighborhood being wholly unacquainted with the pound-net, were very jealous of the stranger that came among them with such destructive apparatus. They watched Mr. Snediker's movements closely for several weeks, and after seeing the enormous quantities of fish taken by him, at once informed him that he must take his "traps" and leave the country. Refusing to comply with their demands, a number of them sawed off the stakes of the pound even with the water and carried the netting to the shore, assuring Mr. Snediker that if he attempted to put it down again they would destroy it. Seeing it was impracticable to continue the fishery here, he decided to seek some more favorable locality. Before leaving he sold the stakes that remained in the water to a resident fisherman, who obtained from them a pattern of the pound, and in a short time had one properly arranged for fishing. This was also destroyed by the fishermen, but not until enough had been learned to convince them that pound-nets could be used with great profit; and within a year from that time 12 pounds were fished in Mobjack Bay. In 1879 the number had been more than doubled, and on our visit to the region, in 1880, we found that every available site was taken up, and often three, or even four, nets were placed in line, the leader of one being attached to the outer end of another, for the purpose both of economizing space and of securing the fish that chanced to be passing at a distance from the shore.

Mr. Snediker on leaving New Point proceeded to the Eastern Shore of the Chesapeake, and associated with himself one of the most popular fishermen of the region, hoping in this way to prevent any organized

opposition on the part of the residents against the use of the pound. In this way he was successful in avoiding any open hostilities, and it was not long before others adopted the new apparatus.

Though the pound-net was introduced into the Chesapeake against the prejudice of the fishermen, it has entirely revolutionized the fisheries of Virginia. Prior to 1870 the fisheries of the region were of little importance, being carried on almost exclusively by farmers, who fished with hand-lines and drag-seines for a few weeks in the spring and fall, their chief object being to secure a supply of fish for themselves and their neighbors; while to-day the Chesapeake is the center of one of the most important shore fisheries in the United States. The pound-net has not only more than doubled the catch of ordinary fishes, but it has brought to the notice of the fishermen many valuable species that were previously almost unknown to them, the most important of these being the Spanish mackerel. In 1880, 162 pounds were fished in Virginia waters, with two others located at Crisfield, Md., just above the Virginia line.

As the pound-net is such an important apparatus in the Spanish mackerel fishery, a brief description will not be out of place. The accompanying diagram (Plate III) represents the particular kind of net used on the shores of Northampton County, Va. All pounds are constructed on a similar principle, though they differ considerably in size and shape in different States. Few are provided with pockets, and many have only one heart.

The leader and hearts are vertical walls of netting, extending from the surface to the bottom, and simply answer the purpose of directing the fish into the pound, which has not only sides but also a bottom made of netting, there being but one opening (A B) through which the fish can enter or escape. This opening is rectangular in shape; it is about three feet wide, and extends from top to bottom, the netting being so arranged that the aperture can be entirely closed before the pound is lifted. The poles, M, N, A, C, D, &c., to which the netting is attached, are from 4 to 8 inches in diameter, each being driven from 5 to 8 feet into the mud or sand of the bottom by means of a maul or pile-driver. The hearts and bowls are placed in water 15 to 18 feet deep. From these the leader extends to within a few yards of the shore. It varies greatly in length according to the slope of the bottom, the average being about 150 fathoms. The netting is of ordinary material with a three-inch stretch-mesh. The hearts are made of stouter twine, having a mesh of $2\frac{1}{2}$ inches. The opening to the "Big Heart" is 25 feet across, while that to the "Fore Bay" is only 8 feet. The pound or bowl is a rectangular inclosure 45 by 60 feet. The netting of which it is composed is of heavier material than that used for either the leader or the hearts, the mesh being one inch from knot to knot. The pocket is simply a bag of netting, 15 to 30 feet square and 6 to 8 feet deep, in which the fish are placed when, for any reason, it is found desirable to keep them

alive for some time before marketing them. In many localities where the bottom is level or slopes very gradually, two, three, or even four, pounds are placed in line, one outside of the other, in order to intercept any fish that may be swimming beyond the reach of the first one. The fish, striking the leader in their migrations along the shore, at once attempt to swim around it by going into deeper water, and are naturally led through the hearts into the pound, their habit of moving in curves rather than by angular turns making their escape quite difficult. If, however, the pound becomes well filled with fish and they are allowed to remain in it for a considerable time, some of them succeed in finding the opening A B and others soon follow them into the inner heart, from which they find less difficulty in escaping. It is known that many fish pass out in this way, for large quantities are sometimes seen in the pound before the hauling time arrives, which when the net is lifted a few hours later are found to have made their escape. Another proof that the fish often escape from the nets is found in the fact that nets fished twice a day will stock a third or a half more than those that are visited but once in twenty-four hours. In properly constructed pounds, however, only a small percentage of the fish are successful in reaching the outer waters, for even though they may pass out of the bowl, they are apt to be led into it again before they succeed in running the gauntlet of both hearts.

The pound, as described, costs about \$1,000, if we include the second set of netting, which must be used when the first is taken out to be dried and repaired. In the warm waters of this region the netting cannot remain down more than two or three weeks without being seriously injured. Three or four men are required for fishing a pound-net, though by adding one or two to the force several nets are frequently tended by the same gang.*

The average stock for marketable fish during the season for this locality is about \$4,200 to the net; the marine species, named in order

*The nets are usually fished at slackwater, as at this time they are more easily lifted. As the hour of low-water approaches, a boat with a crew of three or four men is rowed out from the shore to the pole P. A man at once unfastens the line that holds the bottom of the pound to its base; after which the boat is pulled to the poles G, Q, R, F, K, E, &c., in the order named, until a circuit of the pound has been made and the lines that hold the bottom of the net in position have been loosened. The top of the net at C is then lowered into the water and the boat passes over it into the pound, after which the netting is again raised and fastened. The boat then proceeds to the mouth of the pound, and two men, by means of ropes attached to the lead line at the bottom of the opening A B, raise this portion of the net entirely out of the water, placing the weighted line which forms the lower side over the gunwale of the boat, thus effectually cutting off all means of escape. The men then take position in either end of the boat and gradually raise the net toward the poles P and C, driving the fish around towards G and D. This work is continued until the fish have been driven past Q and I, when the netting is pulled up on the opposite side of the boat and the fish are confined in the small basin between it and the outer side of the pound. The weighted line at the bottom of A B is now thrown off, and the boat is gradually pulled towards the outer end, the basin growing constantly smaller until the fish are brought into a limited space at K, when they are at once transferred to the boat by

of value, being Spanish mackerel, tailors, trout, sheepshead, porgies, and mixed fish. If the value be neglected and the number of individuals taken be considered, the order should be changed so as to read: trout, tailors, mackerel, mixed fish, porgies, and sheepshead; in addition to the refuse fish, which are either thrown away or used for fertilizing purposes.†

On the western shore of the Chesapeake the pounds are much smaller and the catch is proportionately less, while the fishing season is also different. Here the pounds are put out in time for the run of shad, which begins early in March and continues till the last of May. After the shad season is over many of the nets are taken up. Almost none remain down throughout the summer, though a number are fished in the fall for trout and other species. On the eastern shore the law allows pounds to be fished only between the 25th of June and the 1st of October, during which time they are lifted regularly every day when the weather will permit.

10.—FISHING SEASON FOR THE DIFFERENT LOCALITIES.

Owing to the enormous extent of sea-coast over which Spanish mackerel are taken and to the variation of the fishing season with the locality, these fish may be seen in the New York markets during a greater part of the year. According to the report of the Fulton Market dealers, their first appearance in 1879 occurred in April, when 98 pounds were received. The quantity gradually increased till July, during which month 114,309 pounds were handled. From this date the catch fell off rapidly until in November only 657 pounds were received, and in December but a single mackerel was seen in the market.

The fishing season for Long Island and New Jersey extends over several months; but the bulk of the catch is taken between the 20th of August and the 20th of September; and, allowing for Sundays and

means of dip-nets. When there is a large run of "scrap fish," or when the catch is large, a signal is given and a flat-boat or scow is sent out from the shore to receive the surplus. It is taken to the point K on the outside of the net, and the worthless fish are thrown into it as fast as the marketable ones are sorted out. Frequently both boats are loaded and the fish are culled after reaching the shore.

After the fish have been secured the netting is thrown off, and the fishermen proceed to re-set the pound, drawing the bowl into place by means of ropes which extend from the tops of the stakes through rings at their bases to its lower corners and sides. The boat first proceeds to the opening A B, and after this has been properly secured it passes out of the pound and visits the different stakes in their order until all the lines have been fastened. The pound is now ready for fishing, and is left to itself until the next slackwater, while the fishermen are icing and boxing their catch.

†According to the best-informed fishermen, 100,000 trout, 40,000 blue-fish, locally known as tailors, 30,000 Spanish mackerel, 10,000 mixed fish, 3,000 porgies, and 1,000 sheepshead represent the catch of the average pound for 1879. The money value of the catch is divided among the species as follows: Mackerel, 36 per cent.; tailors, 24 per cent.; trout, 21 per cent.; sheepshead, 6 per cent.; porgies, 5 per cent.; mixed fish, 8 per cent.

stormy weather, there are ordinarily only 20 good fishing days, though small quantities are taken almost every day during the stay of the fish on the coast.

In the Chesapeake the fishing season is somewhat longer, owing perhaps to the warmer temperature of the water in the early spring. It begins late in May, and is at its height from the 10th of June to the 1st of September, when the mackerel start for the ocean.

11.—DISPOSITION OF THE CATCH.

Almost the entire catch of Spanish mackerel is consumed in a fresh state. A few are salted by the fishermen of North Carolina, who, owing to their ignorance of the value of the species in the Northern markets, as well as to the lack of suitable shipping facilities, seldom market their catch in a fresh state. Those salted are not considered very valuable, and the inhabitants are seldom willing to pay more than \$5 or \$6 a barrel for them, placing them on a par with the blue-fish and other common species. It is doubtless true that the fine flavor of the mackerel is very much impaired by salting, and that as a salt fish it is inferior to the common mackerel (*Scomber scombrus*), with which every one is familiar.

In 1879 the owner of the oyster and clam cannery at Ocracoke Inlet purchased small quantities of mackerel and put them up in two-pound cans, but the business was very limited, and no extensive trade was developed, only a few hundred cans having been prepared. Recently, at the suggestion of Professor Baird, experiments were made in canning the Spanish mackerel at Cherrystone, Va., for the purpose of ascertaining their relative value as compared with other kinds of canned fish. The report from the canneries is to the effect that they were no better than fish of ordinary grades, though there seems to be a difference of opinion on the subject. However this may be, there is certainly no prospect of an extensive business either in the salting or canning of the species, as the demand for the fresh mackerel is sufficient to offer an outlet for all that can be secured; while the price ranges so high as to make their canning or salting entirely impracticable.

As a fresh fish, the Spanish mackerel has few equals. It is one of the most valuable species taken in the United States, and is a great favorite with epicures. The price paid for the mackerel in the different markets is often extravagant. Instances are not uncommon where the wholesale price has exceeded one dollar per pound. The first fish sent to New York in the spring usually sell as high as 75 cents a pound, and the price does not fall below 60 cents for some time; but as the quantity increases the price is gradually reduced, until, at times of oversupply, when the market becomes glutted, they occasionally sell as low as 6 or 7 cents a pound. The average wholesale price in New York in 1880, for all grades, is said to have been about 18 cents a pound. Mr. C. W.

Smiley, who has made a careful study of the Philadelphia market, puts the average price for that city at $16\frac{1}{2}$ cents per pound during the same period. The fish taken in the northern waters reach the market in much better condition than those shipped from a distance, and for this reason they sell more readily and at better figures. They are, as a rule, much larger and fatter than those taken in Chesapeake Bay, this fact alone making considerable difference in their value. While the Virginia fish are selling in New York at 15 cents, the larger ones from Sandy Hook and Long Island frequently bring more than twice as much.

Many of the fishermen of the lower Chesapeake do not ship their own fish, but sell to the dealers in Norfolk and other places at 7 to 10 cents apiece. Others pack in ice and ship directly to Baltimore by steamer; but, as their facilities for packing and shipping are limited, the amount realized, after deducting the necessary expenses, is little, if any, in advance of that received by parties selling in Norfolk.

The principal markets, in their order of importance, are Baltimore, New York, Norfolk, and Philadelphia; from these points the catch is distributed to the larger cities of country, where the fish are consumed by the wealthy classes, few going into the country towns of the interior. Few cities keep any accurate statistics of their fish trade, and for this reason it is impossible to give the quantity of mackerel handled by their dealers. No figures can be given for the Baltimore trade, though it is safe to say that the merchants of that city handle fully three-fourths of a million pounds annually. The report of the New York Fish-Mongers' Association shows that 274,913 pounds were handled in that city in 1878. This quantity, according to the same authority, was increased to 309,168 in 1879, and to 390,000 pounds in 1880. Mr. Smiley, in his report on the Philadelphia market for 1880, gives the quantity of Spanish mackerel handled as 65,880 pounds, valued at \$10,870. Mr. W. A. Wilcox, secretary of the Boston Fish Bureau, estimates the quantity handled in Boston in 1879 at 15,865 pounds, while that in 1880 was about 20,000 pounds.

12.—STATISTICS OF THE FISHERY.

It is not possible to state the exact quantity of Spanish mackerel taken by the fishermen of the United States during any season, but a careful study of the fisheries in the interests of the Fish Commission and Census enables us to give the following table, compiled from the preliminary statistical reports recently prepared by Col. Marshall McDonald, Mr. A. Howard Clark, and the writer, for publication by the Census Office. The catch for New York is obtained from the manuscript notes of Mr. Fred. Mather, while the figures for the Gulf of Mexico are gathered from data forwarded by Mr. Silas Stearns.

Table showing by States the quantity of Spanish mackerel taken in 1880, and the total catch for the United States.

State.	Pounds of mackerel taken.
Massachusetts	60
Rhode Island	2,000
Connecticut	1,200
New York	25,000
New Jersey	200,000
Maryland	18,000
Virginia	1,609,863
North Carolina	10,000
South Carolina	1,000
Eastern Florida	500
Gulf of Mexico	20,000
Total	1,887,423

From the above table it will be seen that Virginia produces 85 per cent. of all the mackerel taken, and that the New Jersey fishermen catch over two-thirds of the remainder. This, as has already been remarked, is largely due to the ignorance of the fishermen of many localities, both as to the abundance of the fish and to the proper methods of catching them. That the fishery will soon be extensively developed in other places seems quite certain.

C.—ARTIFICIAL PROPAGATION.

13.—CAUSES THAT LED TO THE EXPERIMENTS, AND OBJECTS TO BE ACCOMPLISHED.

The discovery of the spawning grounds of the Spanish mackerel was the result of an arrangement between Professor Baird and General Francis A. Walker, Superintendent of the Tenth Census, for gathering facts relating to the fisheries of the country, including notes on the life history of the more important species as well as the statistics for the different fisheries. To this end the writer visited the Southern coast in the winter of 1879-'80 for the purpose of studying the marine fisheries, while Col. Marshall McDonald, fish commissioner of Virginia, went to the same region to gather material for a report on the river fisheries of our Southern seaboard, special attention being given by him to the fresh-water fishes and the more important anadromous species like the shad, alewife, and sturgeon.

There are several localities along this coast where both the marine and anadromous species are taken together by the same parties. At such points it was found desirable to work together, and the fisheries of certain districts were carefully studied in this way. In the Chesapeake the anadromous and marine species are taken in nearly equal quantities. In order to better understand the fisheries of this region, we spent a week together at New Point, studying the various questions that presented themselves. While engaged in this work we learned of the abundance of Spanish mackerel, and noticed that many of those taken were nearly ripe. A further investigation of the subject proved

that the Chesapeake was an important spawning ground for the species, and that the spawning season continued during the greater part of the summer. Colonel McDonald at once communicated these facts to Professor Baird by telegraph, and a little later the writer reported at Washington in person.

The great success that had attended the work in the hatching of shad, salmon, and whitefish, had definitely settled the question of the practicability of increasing the food supply by artificial propagation. Knowing the value of the Spanish mackerel, Professor Baird was anxious to include this in the list of fishes to be propagated by the Commission. It therefore became necessary to learn more about the spawning habits of the species, and to ascertain how and in what quantities the eggs could be obtained, and the kind of apparatus necessary for successfully hatching them. Accordingly the writer was requested to return to the Chesapeake to gather the necessary information, and to undertake the work of actually hatching the fish.

14.—PREPARATIONS FOR THE WORK.

It was not thought desirable to arrange for extensive experiments, but rather to give particular attention to the questions which bore upon the practicability of the artificial propagation of the species, and as soon as these had been settled to return to Washington, after which the question of extensive operations could be considered. During the earlier observations almost nothing had been learned regarding the character of the eggs, and it was necessary to again visit the spawning grounds before any definite ideas could be formed as to the kind of apparatus necessary for the work. Accordingly, on June 21, I secured a quantity of nickel-plated wire-cloth, and with this simple outfit started for the fishing grounds, intending to improvise the apparatus after reaching the Chesapeake. On a previous visit it had been ascertained that several pound-nets were fished in the vicinity of Crisfield, Md., and that considerable quantities of mackerel were taken in them as well as in the gill-nets of the fishermen of Tangier Island, only a few miles distant. Crisfield is a city of some importance on the eastern shore of the bay, a few miles north of the Virginia line. It was, for various reasons, selected as the most available place for the experiments.

15.—HATCHING OPERATIONS.

Arriving at Crisfield on the morning of June 22, I immediately called upon Mr. J. E. N. Sterling, the owner of the pound-nets, and made known to him the object of my visit. He at once became interested in the work, and, besides giving every opportunity for visiting the pounds and examining the fish, instructed his men to render such assistance as might be desired.

During our stay of ten days the run of mackerel was small, and the catch for this reason was very limited; but enough were taken to give an opportunity for settling most of the questions that presented themselves, and to furnish an abundance of eggs for the experiments. A visit to the pounds proved that the relative number of males and females in a school varied considerably. At times the males were taken in greater numbers, while again the females were more abundant. It was further found that a large percentage of the fish taken were still green, though ripe males were not uncommon, and half a dozen or more were seen at every lift of the pound. Ripe females were less plenty, though many containing a few clear eggs, which were usually too immature for hatching purposes, were captured.

On our first visit to the pound-nets one ripe female was found, from which about 50,000 eggs were taken and successfully impregnated. The manner of "stripping" the mackerel was similar to that employed with the shad and other species, the fish being held firmly with the left hand, while with the right the eggs were gently pressed from the abdomen into a large pan partially filled with water, where they were easily impregnated by being brought in contact with the milt of the males.

The eggs of the mackerel, and indeed of all other fishes thus far examined, are covered by an outer shell or membrane which surrounds and protects the germinal mass. When first excluded from the female the egg is soft and shapeless, owing to the looseness of this covering membrane, which is always more or less wrinkled or folded. It has but one opening in its surface, this being a small porous disk called the micropyle, through which the spermatozoa find their way to the germ cells. When placed in water in which the milt has been introduced, an absorption of water begins, and soon the membrane becomes somewhat distended and finally expands to its fullest extent, being separated from the germinal mass by a cushion or layer of water, which serves to protect the embryo in its earlier stages of development, and in addition furnishes oxygen to sustain the life of the fetus. When fully distended by the water the egg is much larger than at the time of its exclusion from the parent, the relative increase varying with the species from one-fifth to over half of the entire bulk. The egg-membrane becomes toughened during the process, and within half an hour after impregnation has assumed a globular form and is so strong that it can with difficulty be broken by pressure between the thumb and finger. This increase in the size of the eggs, due to the absorption of water, is, as has been said, very marked in many species, and a quantity of eggs that before impregnation scarcely more than half fill a dish, will, when fully expanded, often more than fill the vessel so that some will be forced over the top. When eggs have thus increased in bulk they are said by the spawn-takers to have "come up," and the vessel containing the milt should then be replaced by clean water, after which they are ready for the hatchery. A slight absorption of water often,

though not always, takes place in the absence of spermatozoa, but in such cases the action is slower and the membrane is never expanded to its fullest extent. By this slighter expansion, as well as by the greater delicacy of the membrane, the spawn-taker usually knows that the eggs have not been properly fertilized.

The mackerel were examined as soon as they were taken from the pounds, and when ripe females were secured they were at once "stripped," and owing to the abundance of ripe males no difficulty was experienced in getting milt for impregnating them. As the pounds were some distance from the harbor, the eggs were carefully tended during the journey to the wharf, clean water being added every half hour to keep them in good condition.

It was at once seen that the eggs of the mackerel, like those of the cod, belonged to the class known as floating eggs, as after impregnation most of them floated at the surface, though a few remained suspended in the water at different depths, while others sank slowly to the bottom. When, however, there was the least current they were readily carried about by it, and became generally distributed throughout the liquid.

A small oil-globule was noticed in each egg. This served to keep the egg in position, remaining constantly at its upper surface, while the fish formed with the curve of its back at the lowest point directly opposite.

As the eggs were only a 22d to a 28th of an inch in diameter and perfectly transparent it was difficult for one not accustomed to handling them to detect their presence, and it was not at all surprising that the fishermen had never noticed them floating on the surface of the bay. In fact, had their attention been directed to them, they would probably have had no idea of what they were.

The number of eggs capable of impregnation that can be taken from a female at one "stripping" varies, with the size and condition of the fish, from 25,000 to 100,000, this being but a small portion of the number actually contained in the fish; for, as has been said, the eggs ripen very irregularly, some being fully developed while others are still green.

As soon as an egg has reached maturity it frees itself from the enveloping membrane and passes down through the proper duct, and is soon excluded from the fish, to make way for others. Thus the spawning season for a single individual probably lasts for more than a month.

The fish from which eggs were taken by me were so roughly handled that few survived the operation, though with proper care it seems probable that they could be penned up and "stripped" from time to time, until a greater part, if not all, of the eggs were secured. The mackerel is, however, a delicate fish, and the question of penning and handling it is by no means settled.

Our experiments with the eggs of the codfish had given us some experience in the treatment of floating eggs, which proved very valuable in suggesting the proper kind of apparatus to be used at this time. On reaching the harbor the eggs were allowed to remain in the pans until a

crude hatching-box could be made for holding them during the night. This consisted simply of a small wooden box, with a wire-cloth bottom. When completed it was placed in the water, and, after being properly secured to the piling of a wharf, the eggs were poured into it. The following morning a number of larger and better boxes were made. The one giving the best results was so arranged that the smallest waves would cause a flow of water into it, and thus keep the eggs in constant motion. It was very similar in shape to the boxes used in hatching the eggs of the cod, having, in addition to the wire-cloth bottom, openings on two sides, even with the water-line. •Just below these, on the outside of the box, were wooden floats about three inches wide, these being placed at an angle with the surface of the water, so that a portion of each wave, as it came in contact with the float, would run up the slight incline and, after reaching the highest point, pass down through the wire-cloth into the box, giving a constant circulation, the water being introduced from above and passing out through the bottom, thus giving the best possible motion to the eggs. Other boxes were arranged in the ordinary way to utilize the action of tides and currents; these were set obliquely in the water, so that the current would force the water through the wire-cloth bottom, thus keeping the eggs in constant motion.

The first eggs secured were washed out of the box during a storm and were lost, but the other boxes were at once provided with covers, to obviate any further loss from this source. From this time little difficulty was experienced, and the eggs were easily hatched. The number of eggs taken during the experiments was about half a million, these being secured from 8 or 9 females, at different times, the largest number taken from any fish being estimated at 100,000. The loss in hatching, if we except the eggs washed out, was very small, and in one instance did not exceed 10 per cent., while 60 or 70 per cent. of nearly every lot developed into young fish.

The time of hatching varied greatly with the temperature of the water, the embryo developing much more rapidly in warm than in cold water. The average temperature during the experiments at Crisfield was 84° Fahr. Under these thermal conditions the line of the fish could be readily seen by the unaided eye 10 hours after the egg had been brought in contact with the milt. In 15½ hours the first fish were seen; 2½ hours later, or 18 hours from the fish, fully half of the eggs had hatched, and inside of 20 hours all were out. Later experiments showed that in water at a temperature of 78° 24 hours were required for hatching. It is thus seen that the eggs of the mackerel develop more rapidly than those of any other species with which the Commission is familiar.*

* During the experiments with the eggs of the mackerel many moon-fish (*Chætodipterus faber*) were taken in the pounds. A number of spawning fish were found among them, from which I secured several lots of eggs that were successfully hatched. These fish spawn in Chesapeake Bay during June, July, and August. The eggs are buoyant, and though a trifle larger than those of the mackerel they hatch in the same time. This is the first time that eggs of the moon-fish, or porgy, as it is more commonly called, have been artificially hatched.

Eggs of the shad require an average of three to five days, while the period of hatching for the other species handled is much greater. In water at 45° Fahr. eggs of the cod have been hatched in thirteen days; but when the temperature is reduced to 31°, as is not unfrequently the case in some of the bays and coves along the shores of Northern New England in mid-winter, the time of development is increased to fifty days. The eggs of the salmon and whitefish require even a longer period.

When first hatched the young fish are about one-tenth of an inch in length and are almost colorless. The food-sac, when compared with other species, is quite large in proportion to the body, the anterior margin reaching nearly to the end of the lower jaw; and the tail is relatively much smaller. The food-sac, containing as it does the oil globule already mentioned, is quite buoyant, and brings the fish to the surface of the water, where it remains belly uppermost for several hours. While in this condition it lies nearly motionless, though it occasionally indulges in spasmodic movements similar to those noticeable in its efforts to free itself from the shell. In a few hours it becomes slightly more vigorous, and moves about to a limited extent, going to the depth of an inch or more below the surface. When a day old the food-sac becomes less prominent, and also less buoyant, so that the fish experiences little difficulty in swimming at various depths.

It is found that both eggs and fish are quite hardy, and that little difficulty need be expected in hatching the eggs or in transporting the fry to any distance desired. In one case eggs taken at six in the evening were allowed to remain in a basin of water till the following morning, when clean water was supplied, after which they received no further attention. A few hours later a large percentage of them hatched out, the fish being in excellent condition.

About 40 young mackerel were confined in a goblet for two days without change of water before the first ones died. Others were placed in water that was allowed to cool gradually, and then suddenly transferred to water ten degrees warmer, but this change of temperature did not seem to injure them in the least. In fact it seems probable that wrong impressions have prevailed for some time with reference to the care necessary for the eggs and young of different species, and further experiments in this line will doubtless prove that both are much more hardy than has been supposed.

Experiments in other places.—When the necessary information had been gathered at Crisfield regarding the treatment of the eggs, it was thought desirable to proceed further down the bay, where the mackerel were more plenty, to find a more favorable locality for the establishment of a hatching station, as well as to enlist the sympathies of the fishermen of that region. Accordingly we visited Hunger's Creek, where the pounds of Dr. J. T. Wilkins are located, and spent a number of days in examining the catch and gathering additional information. Dr. Wil-

kings at once manifested a lively interest in the experiments, and assisted us in every possible way, accompanying us to the fishing station and helping in the examination of the fish. During our stay the weather was somewhat stormy, and the pounds could not be fished with any regularity. This interfered greatly with the results, as the mackerel seem to throw all their ripe eggs when remaining long in confinement. Plenty of males were seen with the milt running, but no thoroughly ripe females were secured.

16.—CONFIRMATION OF EXPERIMENTS.

Early in July the fish-hatching steamer Lookout, under the direction of Maj. T. B. Ferguson, proceeded down the bay, and made a number of experiments with the eggs of the species, all of which confirmed the results of my own observation. Mr. John A. Ryder, the embryologist of the Commission, accompanied the party, and, having a good microscope at hand, he improved the opportunity for making drawings of the embryos in different stages of development. Both Major Ferguson and Mr. Ryder watched the development of the species with considerable interest, and carried some of the young fry to Saint Jerome Creek, where their subsequent growth could be carefully studied.

17.—PRACTICAL RESULTS.

The experiments conducted by us naturally lead to the conclusion that the artificial propagation of Spanish mackerel is not only possible, but entirely practicable. The fish are very abundant in certain sections from the first of June until late in September, giving excellent opportunities for examination and study. The spawning season also lasts during several months, giving time for extensive operations; while the fact that the eggs are deposited gradually during a long period renders it highly

* In the summer of 1881 a station was established at Cherrystone, Va., on the eastern shore of Chesapeake Bay, a few miles above Cape Charles, for the purpose of making a further study of the Spanish mackerel. The work was at first conducted by Lieut. Z. L. Tanner, of the Fish Commission steamer Fish Hawk, and later by Colonel McDonald and Mr. Ryder. The last-named gentleman gave his attention to a most thorough and systematic study of the embryology of the mackerel. The advance sheets of Mr. Ryder's report come to us as this article is going to press, and are therefore too late to warrant us in making any extended quotations. We, however, take pleasure in referring the reader to the forthcoming Bulletin of the United States Fish Commission, in which it will appear.

In this report it is stated that comparatively few eggs were secured at the Cherrystone Station, and that, owing to defective apparatus, not more than 25 per cent. of any lot were hatched. He thinks that the spawning-grounds of the mackerel are farther up the bay, and that the eggs are deposited only at night. He does not give the temperature of the water in which the eggs were hatched, but says that the time required for the development of the embryo after the egg had been fertilized was 24 hours. He further states that the young fish begin feeding on the third day after they leave the egg, as traces of food were found in their stomachs at this time. Though unable to identify the food, he thinks it to be composed of several species of small articulated animals that abound in the water in mid-summer. The microscope revealed the presence of teeth in the jaws at the end of the first week.

probable that many ripe fish can be secured. The number of eggs in the mackerel is also greater than that of most species to which the Commission has thus far turned its attention; while the number obtainable for hatching purposes greatly exceeds that of either the shad, whitefish, or salmon.

The short time required in hatching is also a strong point in favor of the artificial propagation of the mackerel. As has been said, with water at 84° F., but eighteen hours elapse from the time of the fertilization of the egg till the young fish comes from the shell; while the average time required for the development of the shad is about four days, and that for the codfish is fully six times as long. Thus five lots of mackerel can be hatched out in the time required for one lot of shad, and thirty-two lots in that required for one of codfish. In this way the Commission would be enabled to hatch a larger number of fish in a shorter time and with a smaller force.

18.—RELATIVE MERITS OF DIFFERENT LOCALITIES FOR THE ESTABLISHMENT OF A HATCHING STATION.

A number of localities are more or less suited for the establishment of a hatching station, in case such a step should be thought expedient; the principal ones are: Mobjack Bay, on the western shore of the Chesapeake; and Cherrystone, Puncoteague Creek, Onancock, and Crisfield, on the eastern shore.

The principal point in favor of Mobjack Bay is that the pound-nets are more numerous in that vicinity than in any other part of the Chesapeake; the catch, however, averages only 150 mackerel daily to the pound, and a majority of the nets are taken up in July, while few, if any, remain after the 1st of August. Another objection is the lack of a harbor affording comfortable anchorage for a hatching steamer in the vicinity of the fishing grounds.

At Cherrystone the pound-nets, though less numerous than at Mobjack Bay, are larger and catch a greater number of Spanish mackerel, the average daily yield being from 500 to 600 to each pound, while the fishing season lasts throughout the entire summer. On account of the large run of mackerel along this shore fewer pounds would have to be visited, and the work could be accomplished with a smaller force. There is also an excellent harbor with 9 feet of water at mean low tide; this being quite free from impurities, a condition very necessary to the successful prosecution of the work.

Both of the places mentioned are, however, open to the same objection, for, being situated near the mouth of the bay, they are somewhat removed from the principal spawning grounds. The water is also much colder than further up the bay, and, for this reason, would be less suitable for hatching purposes. Colonel McDonald, who visited Cherrystone some time after our return to Washington, found the same difficulty in securing ripe fish that has already been mentioned. He

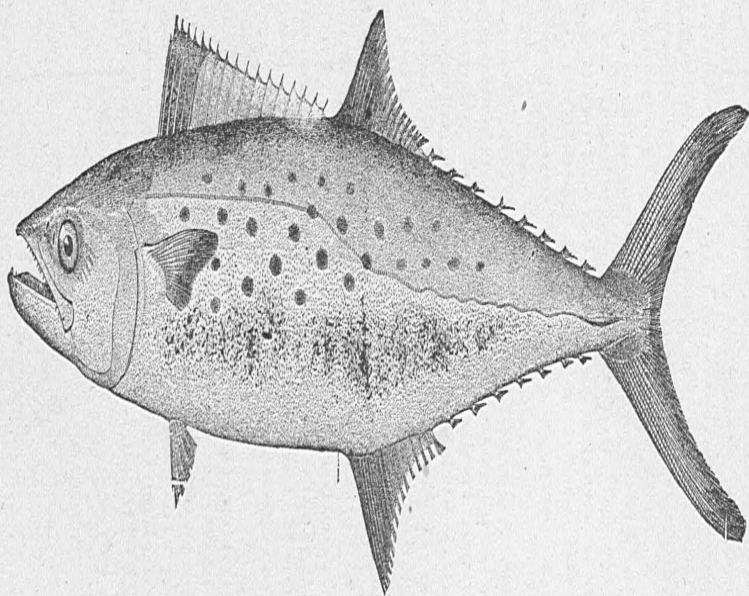
explains this by saying that the eggs of the mackerel do not fully develop until the female has passed into the warmer water; his opinion being that the region was too near the capes.

Puncoteague C^reeek, Onancock, or even Crisfield, Md., would scarcely be open to these objections, as they are considerably farther up the bay, and also nearer the spawning grounds. Any of these would furnish fair anchorage for the steamer, and would be a convenient point from which to visit the various fisheries. In case the tendency for the mackerel to throw their eggs when long confined should prove a serious obstacle in the way of securing sufficient quantities from the pound-nets, these places would possess a great advantage over those first named, as they are in the center of the gill-net fisheries, where the nets are hauled so frequently that the fish would usually be secured before many of their eggs had been lost. In case it should be found necessary to depend on the gill-net catch, no place could be more favorable than Crisfield or Tangier Island.

The fishermen of the Chesapeake manifest the most friendly disposition toward the Fish Commission, and fully appreciate the benefits already derived by them from the artificial propagation of the shad. They are thoroughly interested in the propagation of the mackerel, and realize the importance of this work. Many of them have not only consented to allow an examination of their fish for the purpose of securing eggs, but have kindly volunteered every possible assistance.

Sandy Hook, N. J., presents some advantages for the location of a hatchery not offered by the Chesapeake Bay towns, though there are drawbacks that may render it less desirable. In the first-named locality the mackerel are quite abundant; and those taken, being of large size, would yield a much larger number of eggs than the smaller fish of the South—a matter that may prove to be of great importance, for we must remember that the question of keeping the mackerel in confinement, and of stripping them from time to time until all of the eggs have been secured, is still unsettled. If the question of the transportation of the fry should become important, Sandy Hook would be especially suited for the work, for the young mackerel could be readily shipped to New York, from which point they could be sent to any portion of the coast where it might be thought desirable to introduce them.

SMITHSONIAN INSTITUTION, *January 10, 1882.*



The Spanish Mackerel.

Fig. 1.



Fig. 2.

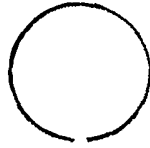


Fig. 3.



Fig. 4.



Fig. 5.

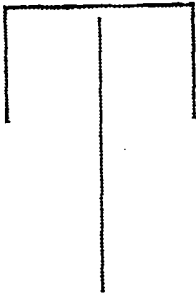


Fig. 6.

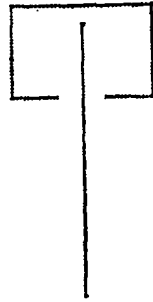


Fig. 7.

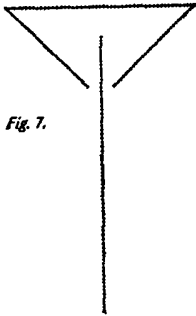
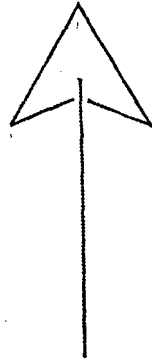


Fig. 8.



Different methods of setting Gill-nets off Sandy Hook.

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