PART III.

THE FOOD FISHES

OF THE

UNITED STATES.

BY

G. BROWN GOODE.

WITH DISCUSSIONS OF THE PACIFIC SPECIES BY DAVID S. JORDAN AND TARLETON H. BEAN, NOTES ON THE FISHES OF THE GULF OF MEXICO BY SILAS STEARNS, AND CONTRIBUTIONS FROM JOSEPH W. COLLINS, N. E. ATWOOD, MARSHALL McDONALD, R. EDWARD EARLL, LUDWIG KUMLIEN, AND OTHER AUTHORITIES.

ANALYSIS.

H.—THE FILE FISHES, PIPE FISHES, AND ANGLERS.

NOTE.—In preparing the following chapters upon the food-fishes of the United States, the authors have avoided all technical discussions, all descriptions of form, all digressions of the kind in which naturalists, even when writing for the general reading public, are so prone to indulge. We anticipate the criticism that the book is of no use in identifying the different kinds of fish, by the statement that we expressly desire that it shall not be. We have tried to present in concise form the information suited to the needs of the fisherman, the fish purchaser, the statistician, and the general reader. Most of our important species can be identified by reference to the plates. If greater accuracy of identification be needed, the inquirer is advised to consult Jordan's Synopsis of the Fishes of North America, which forms Bulletin No. 16 of the United States National Museum series.

46. THE OCEAN SUN FISHES—ORTHAGORISCIDÆ.

The family *Orthagoriscidæ* is represented in the Western Atlantic by two species.

The common Sun Fish, *Orthagoriscus mola*, with its compressed, disk-shaped body and its elongated dorsal and anal fins, is one of the most grotesque of sea animals. This species is found in all parts of the world in temperate and tropical seas, and has been recorded from the coasts of Japan and California. It occurs also in the Mediterranean and on both sides of the Atlantic. On our own eastern coast it may be observed every summer, from the Banks of Newfoundland to Florida. It has not been seen in the Gulf of Mexico, but there is one instance of its capture at the Bermudas. It rarely frequents the New England coast except in summer. In the winter of 1874–'75 two large specimens were taken at the mouth of the Saint John's River, Florida.

Sun Fishes attain a length of seven or eight feet and a weight of seven or eight hundred pounds. They may be seen along our coast on almost any calm summer's day. As many as ten or twelve are often met with in the course of a day's cruise. They float lazily, with one of the bright sides of the body just at the surface. As they float, the waves ripple and break over them, and the heavy pectoral fins move slowly to and fro through the air; thus lying, they are very conspicuous objects, and may be seen at long distances. They spend whole days in this position, and may very easily be approached and harpooned. From this habit of sunning themselves they have gained the name of Sun Fishes.

Their food consists of the jelly-fish, or sun-squalls, which are so abundant along the New England coast in summer. Their jaws, however, are strong, and it would seem probable that they sometimes seek more substantial food.

Nothing whatever is known of the place or time of their breeding: the young are occasionally taken in mid-ocean.

Many individuals are harpooned by our fishermen every summer. They are not applied to any practical use, but are brought to the cities and exhibited as curiosities. The fishermen of Cape Cod sometimes make oil from the livers. This oil is prized highly as a remedy for sprains and bruises.

In the "Transactions of the Royal Society of London," 1740, was published a communication "Concerning the *Mola Salu*, or Sun Fish, and Glue Made from It," contributed by the Rev. William Barlow, in which mention is made of the capture of a specimen near Newfoundland. I am not aware that the suggestions of this author have ever been further carried out.

As a food-fish the Sun Fish is probably the most worthless species in our waters. The flesh is thin and hard, and, when cooked, separates into oil and bunches of tough fibers.

On the California coast, according to Jordan, this species is very abundant, especially in the

Santa Barbara Channel in summer, where it may be seen lying near the surface, or even sometimes leaping from the water. It is known to the Italians as the Mola, to the Americans as the Sun Fish. It seldom appears before June, and disappears in the winter. No use is made of it, as *it is not easily caught, and rarely, if ever, eaten. A specimen weighing 636 pounds was brought* to San Francisco some years ago.

There is a small species, *Ranzania truncata*, much more elongated in form, which has been taken in various parts of the Atlantic and Pacific, but never nearer to our shores than the Bermudas, where an individual of eight inches was captured in 1878.

47. THE PORCUPINE FISHES—DIODONTIDÆ.

SWELL FISHES AND PUFFERS.—*There are four species of this family inhabiting the Atlantic* coast, and two on the coast of California. The best known is the Swell Fish of New England, *Chilomycterus geometricus*. These fishes are commonly known by such names as "Burr Fish," "Ball Fish," "Swell Fish," and "Toad Fish"; while in Southern Florida the names "Porgy," "Puffer," and "Puff Fish" are sometimes used.

With their short, thick, spiny bodies, which they have the power of inflating to twice their ordinary size, and their harlequin-like colors, they are always conspicuous, and are favorite fish for aquaria. After they have inflated their bellies by swallowing air, they turn upon their backs and swim at the surface.

They have the power, when handled, of uttering loud grunting sounds.

No practical use is made of them, but their skins are often stuffed and exposed for sale in the curiosity shops, particularly those at places of popular resort, like Nantucket, Oak Bluffs, Jacksonville, and Saint Augustine. These fish belong to a tropical family, and are only seen in summer.

Nothing definite is known about their food or breeding habits.

48. THE BELLOWS-FISH FAMILY—TETRODONTIDÆ.

Of this family, which is extremely numerous in warm seas, over sixty species being known, there are seven species in the waters of the United States, one of them being found on the California coast. They are summer visitors from a warmer climate, and, like the members of the preceding family, are chiefly important to curiosity hunters. They are known by such names as "Swell Fish," "Bottle Fish," "Bellows Fish," "Egg Fish," "Rabbit Fish," "Globe Fish," "Swell-toad," "Box Fish," "Porcupine Fish," and "Blower."

One species, the common Swell Fish, or Egg Fish, *Tetrodon turgidus*, ranges from Cape Cod to the Gulf of Mexico, being very abundant about the eastern end of Long Island, where a hundred or more are sometimes taken in one haul of a fyke-net.

The Rabbit Fish, *Lagocephalus lævigatus*, is known in New England waters through the occasional visits of stragglers. It is quite abundant in the Gulf of Mexico, where it is occasionally taken with hook and line upon the red-snapper banks. According to Stearns, it breeds about Pensacola in June and July.

This fish, which attains *the length of three feet and the weight of five or six pounds, is used* for food in Cuba, but it is not sufficiently abundant with us to have any commercial value.

49. THE TRUNK FISHES—OSTRACIONTIDÆ.[1]

The Trunk Fishes, *Ostracionticlæ*, are occasionally taken on our coasts, especially to the south of Cape Hatteras. We have five species, one of them being Californian. Like the Porcupine and

[1] See GOODE: A study of the Trunk Fishes (*Ostracionticlæ*), with notes upon the American species of the family. <Proceedings United States National Museum, ii, 1880, pp. 261–283.

Swell Fishes, which have just been described, great numbers of them are preserved for sale in curiosity shops.

The Trunk Fishes appear to have been objects of curiosity in the early days of American exploration, and were evidently among the choicest treasures of the primitive museums of the seventeenth and eighteenth centuries. Their strange shape naturally attracted the attention of travelers, while the ease with which their shells could be preserved then, as now, made them valuable to the curiosity hunters.

No group of tropical fishes is so thoroughly worked out in the writings of the fathers of Natural History as this one. Over two hundred years ago every species of Trunk Fish now taken from the Atlantic was known to and described by the naturalists of Northern Europe, and it is a well-deserved tribute to their discrimination as zoölogists to say that none of the many efforts, which have since been made to subdivide their species, have been at all successful.

Artedi, in his notes upon the different forms of Ostracion, mentions the various collections in which he observed specimens. "The Nagg's Head," "White Bear," and the "Green Dragon in Stepney," to which he very often alludes, seem to have been London taverns where curiosities were kept. He also speaks of seeing them in the museum of Hans Sloane, which was the nucleus of the British Museum; also in the collections of D. Seba, in Amsterdam, of Mr. Lillja, in London, of Mr. (Don) Salteros, in Chelsey, and of seeing various specimens at Stratford, and "in Spring Garden." No other kinds of fishes appear to have been preserved except "*the monk- or Angel-fish Anglis, alias Mermaid-fish*," probably a species of *Squatina*, which he saw in London at the Nagg's Head and in the town of Chelsea. The art of taxidermy was evidently not thoroughly established in 1738.

Of *Ostracion bicaudalis* he remarks, "Vidi Londini, in the White Bear," and "Apud D^{m} Sebam vidi." *Ostracion trigonus* he saw "Apud Sir Hans Sloane et in Nagg's Head"; *Ostracion triqueter* and *O. quadricornis*, "Londini in the Nagg's Head et apud Mr. Lillia."

These specimens were all said to have come from India.

In the West Indies and in Florida the Trunk Fishes are sometimes baked in their own shells, and, when cooked in this manner, are considered by many persons to be great delicacies.

There are instances on record of serious cases of poisoning which have resulted from eating them. These cases occurred in tropical countries, where the flesh of fish often becomes deleterious after a few hours' keeping.

50. THE FILE-FISH FAMILY—BALISTIDÆ.

File Fishes, *Balistidæ*, are found everywhere in tropical and sub-tropical seas. It is supposed that they breed in mid-ocean. There are numerous species in this family, of which nine or ten occur along our Atlantic coast. They belong in warm seas, and only four species are found as far north as New England. With their strong teeth they are able to break the shells of mollusks, upon which they feed. They are known to be very injurious to the pearl fisheries in regions where such fisheries exist. The best known species on our coast is the Orange File Fish, *Alutera Schoepfii*, also called "Barnacle-eater" and "Fool Fish," which is rather common in Southern New England and in the Gulf of Mexico.

This species is conspicuous on account of its bright skin, sometimes of an orange and sometimes of a tawny hue. It attains the length of eighteen to twenty inches, and feeds upon many species of soft marine animals.

There are one or two small species which are of no importance except to the possessors of aquarium tanks, with whom they are great favorites.

The Leather-jacket of Pensacola, *Balistes capriscus*, called "Trigger Fish" in the Carolinas, and at Key West and the Bermudas known as the "Turbot," occasionally finds its way as far north as Massachusetts. It is, however, of no importance north of Florida. In the Bermudas it is considered a valuable food-fish. According to Mr. Stearns, "it is very common in the Gulf of Mexico from Key West to the Mississippi River, and lives in deep waters near the coast on the grounds where Red Snappers and Groupers are caught. It is one of the most abundant species. In regions where it is not eaten it is regarded as a pest by the fishermen from its habit of stealing bait from their hooks. Its manner of taking the bait is rather peculiar, I think, for instead of pulling the line backward or to one side it raises it upward so quietly that the fisherman does not perceive the motion, and then, by careful nibbling, cleans the hook without injury to itself. Expert fishermen, however, can tell by the "lifting of the lead," as it is called, what is going on below, and know what they have to contend against. The usual remedy is to seek other fishing grounds where Leather-jackets are not so troublesome. When one of these crafty fish has been hooked there is not much probability that it can be landed, for its sharp, powerful teeth are almost sure to cut some part of the gear, enabling it to escape. I have several times known of their biting in two the large red-snapper hooks on which they were caught. They remain throughout the year on the fishing grounds, where the water varies from ten to forty fathoms. On these same grounds it is probable that they spawn."

Only adult specimens have been seen in West Florida. More could probably be learned of its spawning habits in the vicinity of Key West, where it occurs in shallow water and quite near to the shore. At Key West it is known as the Turbot, and is a favorite article of food. It is to be seen almost daily in the market.

The skin of this species is used for scouring and polishing purposes at Key West and the Bahama Islands. In the Bermudas also the skin of the Turbot is used by carpenters almost to the exclusion of sand-paper, the former being better adapted for fine work in polishing wood.

51. THE SEA-HORSE FAMILY—HIPPOCAMPIDÆ.

There are one or more species of the Sea-horse family on the Atlantic coast, and also one on that of California. Their strange shapes and interesting habits render them very popular inmates of aquaria, and dried specimens are frequently sold in the curiosity shops in seaside towns.

The ordinary species of the Western Atlantic is the *Hippocampus heptagonus;* this also occurs in Europe. There have been only one or two instances of the capture of this fish north of Cape Cod; one was seined with a school of mackerel on George's Bank in August, 1873. Two or three specimens have been taken at Wood's Holl during the last ten years, and instances of their capture in Connecticut and about the mouth of the Hudson are not rare.

A Sea-horse was described many years ago under the name *H. hudsonius*, but it seems to be identical with *H. heptagonus*. On the New Jersey coast and south to the Gulf of Mexico it appears to be very abundant. An excellent account of the habits of this fish may be found in an article by the Rev. Samuel Lockwood in the "American Naturalist."[1] Three other species occur on our southern coast. *H. ingens*, the Californian species, is very large, often attaining the length of eight to ten inches.

52. THE PIPE-FISH FAMILY—SYNGNATHIDÆ.

The Pipe Fishes, *Syngnathidæ*, which are closely related to the sea-horse, but have small heads and elongated bodies, so that at first sight they closely resemble small eels, are found nearly everywhere on our coasts, living among the eel-grass and feeding upon very minute marine

[1] LOCKWOOD, SAMUEL. The Sea Horse and its young. <Amer. Naturalist, i, 1867, pp. 225–234.

animals. There are three or four species in Eastern North America, but their relations have not been definitely learned. I have observed them in Florida spawning in April, and in Southern New England in July and August. They are of no importance to man except as interesting objects for the aquarium. They are too hard and fleshless even to serve as food for other fishes.

53. THE DEVIL-FISHES—ANTENNARIIDÆ AND MALTHEIDÆ.

The fishes of this group are very grotesque in form and very remarkable in their habits Some of them are pelagic and are met with in tropical seas, especially where there are masses of floating vegetation, whilst others are found in the depths of the ocean. On our coast are several species, the names and distribution of which are given in the list which accompanies this report. Although they are among the most interesting of all fishes, they have no commercial value, and it is therefore inappropriate that they should be discussed in this report. The best known species are the Marbled Angler, *Pterophryne histrio*, and the Sea Bat, *Malthe vespertilio*.

54. THE GOOSE FISHES—LOPHIUS PISCATORIUS.

The Goose Fish or Monk Fish, *Lophius piscatorius*, is common to the coasts of the North Atlantic States and of Europe. In the Western Atlantic the species has not been observed south of latitude 38°, where, according to Uhler and Lugger, it is found in the drains of Worcester County, Maryland, and along the coast of that region, though there is reason to believe that stragglers occur at Cape Lookout (latitude 34° 40′), where the jawbones have been found, and the fishermen claim to know them. It abounds along the coast of New England, and has been found at depths of three hundred fathoms or more off Newport, Rhode Island, and one hundred off Halifax. The limits of its northern range are not known, Nova Scotia being the most northerly point of record. Richardson suggests that the *Thutinameg* or "Wind-fish" of Hudson's Bay, which is said to come to the surface in windy weather only, belongs to this family; and, indeed, this was thought by Pennant to be *Lophius piscatorius*. This is at best extremely doubtful, for its range, as now understood, is limited by the parallel of 50°. It is not known to occur in Greenland.

Instances are on record of its capture in Iceland,[1] and it is said very rarely to occur at the Faroe Islands. It has been found at the North Cape, latitude 71°, and doubtless penetrates to the White Sea. It is found along the coasts of Scandinavia, south to Spain, and throughout the Mediterranean, where it is abundant in the Italian waters. Either this or an allied species occurs at the Cape of Good Hope. On the American coast it occurs at temperatures of 32° to 60°. There is some reason to think that south of Cape Cod it retreats to deep water in summer.

The names of the fish are many; that most commonly in use among the Massachusetts fishermen is "Goose Fish." In Maine it is often called "Monk Fish"; in Rhode Island, "Bellows Fish"; in Eastern Connecticut, "Molligut," and in North Carolina, "Allmouth." The Connecticut name reminds us of the "Greedigut," a fish, probably the same, mentioned by early colonial writers, particularly in the poem in Wood's "New England's Prospect."

In England the same names are in use; also, "Angler," "Fishing Frog," "Frog Fish," "Mermaid," "Round Robin," "Sea Devil," "Toad Fish" (Germany), "Wide Gut," and "Wide Gap." "Kettlemaw" is like the American "Allmouth." Scotland has "Keethie," "Keghie," and "Keithok." The continental languages have at least fifty distinct names in addition.

Goose Fishes are sluggish, slow-moving animals, and are occasionally seen swimming near the surface, though ordinarily found upon the bottom. They feeds upon other fish—often on large ones, their swallowing powers being practically unlimited. Mackerel, sculpins, sea ravens, and

[1] FABER: Fische Islands, p. 58.

dog-fish, crabs, squids, and lobsters have been found in their stomachs by observers of the United States Fish Commission. They often attempt to feed upon each other. The common name refers to the fact that they have been known to swallow live geese. A fisherman told me he once saw a struggle in the water, and found that a Goose Fish had swallowed the head and neck of a large loon, which had pulled it to the surface and was trying to escape. There is authentic record of seven wild ducks having been taken from the stomach of one of them. Slyly approaching from below, they seize birds as they float upon the surface. They annoy the fishermen by swallowing the wooden buoys attached to the lobster pots. Mr. Minot, of Magnolia, Massachusetts, caught one by using his boat-anchor for a hook.

Although they come thus to the surface to feed, the Goose Fish is emphatically a bottom-loving species. "It is adapted," writes the Duke of Argyle, "for concealment at the bottom of the sea—for lying perfectly flat on the sand or among the weeds—with its cavernous jaws ready for a snap. For more perfect concealment, every bit of the creature is imitative both in form and in coloring. The whole upper surface is mottled and tinted in such close resemblance to stones and gravel and sea-weeds that it becomes quite undistinguishable among them. In order to complete the method of concealment, the whole margins of the fish, and the very edge of the lips and jaws, have loose tags and fringes which wave and sway about amid the currents of water, so as to look exactly like the smaller algæ which move around them and along with them. Even the very ventral fins of this devouring deception, which are thick, strong, and fleshy, almost like hands, and which evidently help in a sudden leap, are made like two great clam-shells, while the iris of the eyes is so colored in lines radiating from the pupil as to look precisely like some species of *Patella* or limpet. But this is not all; not only is concealment made perfect to enable the Lophius to catch the unwary, but there is a bait provided to attract the hungry and the inexperienced. From the top of the head proceeds a pair, or two pair, of slender elastic rods, like the slender tips of a fishing-rod, ending in a little membrane or web which glistens in the water and is attractive to other fish. When they come to bite, or even to look, they are suddenly engulfed, for portals open with a rush and close again—portals over which the inscription may well be written: '*Lasciate ogni speranza voi ch' entrate.*'"

From the time of Ælian every popular essay on the "Habits of Fish" or "Curious Fishes" has told how the Angler entices its prey with its long tentacles. No one has ever seen the performance, and, although the theory is not altogether incredible, it seems more probable that the tops of these organs are intended by their sensitiveness to warn the fish of the approach of its prey than to act as allurements to attract other fishes.

The Goose Fish spawns in summer, in the sounds and at sea along the coast. The eggs are very numerous, enclosed in a ribbon-shaped gelatinous mass about a foot in width and thirty or forty feet long, which floats near the surface. One of these ribbons will weigh perhaps forty pounds, and is usually partially folded together, and visible a foot or eighteen inches from the top of the water, its color being brownish purple. The number of eggs in one of them I have estimated at from forty to fifty thousand. The spawning season on the New England coast is in summer. I have observed the floating eggs in July and August, and in the same months young fish two or three inches long, and undeveloped eggs in the parent fish. The young have rarely been taken except at considerable depths. Their growth is rapid. The adult is commonly four feet long, weighing from thirty-five to forty-five pounds.

The Goose Fish is extensively used for baiting lobster pots. Although not commonly eaten, its flesh is very palatable. The full-grown fish will yield from ten to fifteen pounds of good meat. In Italy it is much esteemed as an article of food, and in parts of Great Britain it is also eaten, the steaks from the neighborhood of the tail being preferred.

I.—THE FLAT FISHES AND FLOUNDERS.

55. THE AMERICAN SOLES—SOLEIDÆ.

AMERICAN SOLES.—The much-prized Sole of Europe, *Solea vulgaris*, does not occur in the Western Atlantic, although attempts have been made to introduce it, and in 1877 two individuals were set free in Massachusetts Bay by the United States Commission of Fisheries. Its nearest representative, the American Sole, is found along our coast from Boston and Nahant to the mouth of the Mississippi River. It occurs in all of the rivers south of the Susquehanna, and is taken in great numbers in the shad seines. It rarely attains a greater length than six inches, and, though edible, is never eaten, and it must be regarded as of extremely small importance. There are also two or three other fishes belonging to this family in our Southern waters which are insignificant in size and of no importance whatever.

Aphoristia atricauda is a very small species of Sole, the only genuine representative of the European Sole on our Pacific coast. It reaches a length of six inches, and is occasionally taken in San Diego Bay. It has no economic value.

TURBOT AND SOLE IN AMERICA.—A Philadelphia writer has lately tried in the newspapers to revive the long-obsolete belief that the Turbot and Sole of Europe occur on our coast. Although he has never seen them himself, and fails to bring forward evidence that any one else has seen them, he insists that they occur in the greatest abundance in New Jersey, particularly in the vicinity of Atlantic City, "and doubtless all along the Atlantic coast from Portsmouth, N. H., to Wilmington, S. C." (*sic*). He upbraids the American public for their incredulity, though this does not surprise him so much when he calls to mind that "our Government Fish Commissioner has actually contemplated sending a steamer to English waters to procure turbot-seed to plant along our shores." He would not be surprised if incredulity were to continue longer "under such official indorsement." He accounts for the ignorance regarding them by the theory that the English trawl-net is unknown in America, and that our fishermen would not know how to catch such fish if they were aware of their presence, and have not become aware of their presence because they have no means of catching them. He intimates that he is preparing to form a company for the purpose of developing a turbot fishery upon our coast; an enterprise "in which but little will be risked, and the results will be a surprise to all." He closed one of his letters to a New York journal with the following appeal: "I trust that you will not let this question subside, but persevere in calling attention to it until we do away with the extraordinary anomaly of this enlightened nation being within reach of treasure that for more than a century they have been unaware of, and have remained persistently blind to."

All this is very entertaining, and furnishes a neat text for a few remarks on the history of this belief, as well as an opportunity for demonstrating to the public a fact which has for forty years or more been known to ichthyologists, that the Turbot and the Sole never have been seen on the western side of the Atlantic, and never will be, unless they are introduced by artificial means.

From the beginning to the end we encounter the well-known sources of confusion—the giving of old-world names to species which resemble in a general way the old-world species which bear them, and the unquestioning acceptance of these names as authoritative, by persons who are not trained to close discrimination.

When Boston was occupied by the British during the revolutionary war, the officers of the fleet are said to have been bountifully supplied with Turbot, which was caught in the neighborhood of an outer harbor. This fact is recorded by Dr. J. V. C. Smith, in his "Natural History of the Fishes of Massachusetts" (Boston, 1833), on the authority of William Ladd, esq., of Maine. He also mentions "a statement of Mr. Parker, the conductor of the marine telegraph," who told him that "many years before, Admiral Sir Isaac Coffin brought out to this country a trawl-net, such as is used on the coast of Holland, for taking Sole for the London markets, with which he succeeded in capturing that delightful fish in Ipswich Bay, which was not before supposed to exist here." The fish found in this manner were no doubt the common Flat Fishes of Massachusetts Bay. The common Flounder, *Paralichthys dentatus*, taken in Provincetown water, where it is commonly called "Plaice," was in 1880 sold in Boston under the name "Turbot." Captain Mackinnon, of the Royal Navy, who visited this country in 1850, conceived the idea that Turbot ought to be found on the shores of the United States, and took pains to search for them with a trawl-net. The nets which he used had been imported ten years before by Mr. Nathan Smith, an American gentleman, who had hoped to introduce them, but had never used them. Captain Mackinnon tried one net at Newport, Rhode Island, and succeeded in taking a number of different kinds of Flat Fish. He carefully refrains, however, from pronouncing any one of them to be identical with the Turbot or Sole, though from the vagueness of his language it is evident that his ichthyological knowledge was very scanty, and that he was not accustomed to observe the differences between the different species of fishes which somewhat resemble each other. His experiences are described at length in his book of travels, entitled "Atlantic and Trans-Atlantic Sketches, Afloat and Ashore" (Harper & Bros., New York, 1852, pp. 166–170). Capt. C. C. Churchill, U. S. A., who saw the results of Captain Mackinnon's experiment, tells us that the fish taken were the common species of New England flat fishes and flounders.

We fancy that the inspiration of the new advocate of the turbot-in-America question, as well as the information upon which he bases his conclusions, was drawn from this very same book of Captain Mackinnon, for he uses many of the same phrases, and he repeats, in almost the same words, Captain Mackinnon's statement: "The fish markets in America are not at all in keeping with the size and wealth of the States," a statement which, however true it may have been thirty years ago, will be amusing to any one who has recently had opportunity to compare the fish markets of America and Europe. The Philadelphia gentleman sums up his evidence as follows:

"The Turbot, Sole, and Plaice are, however, in abundance in your deep-water sand banks. They were caught there in 1812 by English sailors, and in 1880 Turbot have been obtained off Atlantic City, if the 'Baltimore American' is any authority."

The notion that the introduction of the English trawl in America would be novel and would at once open up a field for a fishery industry of boundless extent, deserves a word. The trawl has been assiduously used by the summer collecting party of the United States Fish Commission for ten years past, and also by Professor Agassiz upon various exploring trips. The steamers of the Fish Commission have used it on every portion of the New England coast, and as far north as Halifax. Professor Agassiz has used it in the Gulf of Mexico and on the coast of Florida, and during the present summer, while on the Coast-Survey steamer "Bache," has employed it in running five lines of research at right angles to the coast from Cape Hatteras, at points nearly equidistant between Charleston and Cape Cod, one of them directly out from the entrance to Delaware Bay. These lines were carried from near the shore to a depth of twelve hundred fathoms or more.

In 1854 Professor Baird made a careful exploration of the coast of New Jersey with a special reference to the fishes, and since that time every stretch of coast line from Brownsville, Texas, to Eastport, Maine, has been thoroughly investigated by the officers of the United States Fish Commission. It is true that a new species of fish is occasionally discovered, but the new fishes always belong to one or two classes. These are either swift-swimming species, members of the West India fauna, which come upon our northern shores in summer, or they are inhabitants of waters more than six hundred feet deep, which have never previously been explored. The Turbot and the Sole are shallow-water species, and, had they occurred in our waters, would have been discovered many years ago.

There are twenty-six species of flat fishes on the east coast of the United States. Four of these belong to the same family with the Sole, but are utterly worthless as articles of food. The nearest relative of the Sole is often called the American Sole, *Achirus lineatus*, and is known on the coast of New Jersey as the Hog-choker, Cover-clip, or Cover. Of the other flat fishes only two are positively unfit for food, and these two, strangely enough, are the representatives of the subfamily *Rhombinæ*, to which belong the Turbot and Brill of Europe. One of these, *Lophopsetta maculata*, is sometimes called the Spotted Turbot, and in New Jersey is called Window-pane, or Daylight, because it is so thin that when held to the light the sun can be seen through its translucent flesh.

The most important Flat Fish is the Halibut, which is identical with that of Europe. This species, and the Pole Flounder, which has recently been brought to light in our waters by the Fish Commission, are the only two of the number referred to that are found on both sides of the Atlantic. We have in our waters an abundance of flat fishes, some of which, for instance, the common Flounder of the New York market, *Paralichthys dentatus*, are probably fully equal to the Turbot for food uses. In fact, it may be had in the New York restaurants and hotels under this name. Another fish, *Platysomatichthys hippoglossoides*, resembling the Turbot in flavor, is sometimes brought to New York in winter. It is found at great depths on the coast of Newfoundland, and is often called the American or the Newfoundland Turbot. The Pole Flounder is very similar to the Sole in flavor and in the texture of its flesh, but it unfortunately inhabits somewhat inaccessible localities at great depths, and it is hardly to be expected that, with the present supply of excellent food-fish to be obtained at so much smaller expense, our fishermen will take the pains to go in search of it. That the popular taste for flat fish is already cultivated is shown by the fact that, in 1879, 1,796,000 pounds were sold in New York alone.

It is needless to refer to the efforts of the United States Fish Commission to introduce Sole; they are familiar to all who are interested in the subject. The introduction of the trawl-net has been for many years under consideration, but this expensive mode of fishing does not seem to be required at present, since the supply of fine-flavored food-fishes is more than equal to the demand. With an eye to the interest of the American fishermen, Professor Baird has recently detailed an attaché of the Fish Commission, one of the most experienced fishermen of Massachusetts, to study the trawl fishery in the German Ocean, and his report will soon be published.

Finally, it may not be amiss to state that Mr. E. G. Blackford, of Fulton Market, New York, has for some time been authorized by the Commissioner of Fisheries to pay twenty-five dollars to any one who should present a true Turbot or a true Sole, caught on this coast. This offer is still standing.[1]

[1] Forest and Stream, xv, No. 6, September 9, 1880, pp. 103, 104.

56. THE PLAICE—PARALICHTHYS DENTATUS.

The Plaice, Summer Flounder, or Turbot Flounder, *Paralichthys dentatus*, is, next to the Halibut, the most important flat-fish on the eastern coast. It is a member of a genus not existing in Europe, though represented on our own Pacific coast, in China and Japan, and in the Indian Ocean. Its affinities are with the Halibut, which it much resembles in form, and to which it is more similar in flavor than to the Turbot and Brill, so well known in transatlantic fish markets. Our common species was first brought to notice in 1766, when Linnæus received specimens from South Carolina, sent him by Dr. Garden. It seems at that time to have been of recognized commercial importance, since it was one of the few received by Linnæus from Garden which had a common name. In South Carolina at this time it was called Plaice, and this is a name which is now accepted in the New York market and about Cape Cod, although it has never been recognized by those who have written books on American fishes. The fishermen of the Saint John's River also use the name Plaice, but whether for this species has not been determined. In Connecticut, North Carolina, and in Florida, east and west, as well as on other parts of the coast, the names Flounder and Common Flounder are current. In New York and New England the name Summer Flounder is also frequently heard. In Rhode Island the names Brail and Puckermouth are used, the former doubtless a modification of the English name Brill, while on the bills of fare in Boston and New York hotels it is often called the Deep-sea Flounder, at least since the Pole Flounder has been brought to notice by the Fish Commission, and has obtained a reputation as a delicious table fish. Fishermen sometimes mistake them for young Halibut, and they doubtless at times are sold under the name of "Chicken Halibut." Turbot Flounder is another name which has been suggested, but, upon the whole, Plaice seems most desirable for general adoption.

This fish is abundant upon the eastern coast of the United States from Cape Cod to Cape Florida, and according to Mr. Stearns' report is also found along the entire Gulf coast. Southward, its range extends at least as far as Paraguay. To the northward it barely rounds Cape Cod. Captain Atwood remembers that in the first half of the present century great quantities of Plaice were found inside the Point at Provincetown. They were so numerous that in one afternoon he caught two thousand pounds. They are now only occasionally taken, and have not recently been seen north of Provincetown, though Storer has recorded their occurrence at Wellfleet. Captain Atwood attributes their disappearance, which was nearly simultaneous with the advent of the blue fish, to the fact that blue fish destroyed their favorite food, the squid, and rendered it impossible for them to live longer in these waters. The Plaice has been much less abundant in Cape Cod Bay within the last thirty years, but there is no evidence of considerable diminution in numbers elsewhere. On the eastern coast of Connecticut and Long Island, where the Plaice fishery is most extensively prosecuted, it is the opinion of experienced fishermen that no change in numbers has been perceptible within the last thirty years. The Connecticut fishermen say that they are frequently so abundant that they have only to throw out and pull in their lines, catching "all they choose," while the bottom seems to be carpeted with them.

Like others of its tribe, the Plaice are usually upon the bottom, where their peculiar shape and color protect them from observation and give them excellent opportunity to capture their prey. In the north they are usually found at a depth of two to twenty fathoms, and in winter move off into deeper water. In New Jersey they occur at lesser depths. Professor Baird records that they are sometimes taken in large numbers by means of nets in the deep slues along the beach. In winter they do not run out so far into deep water, and "at times," says Professor Baird, "seem to be quite torpid on the shallow grounds, suffering themselves to be taken up with oyster-tongs

without making any attempt to escape." Still farther south they are found in the shallowest of water. The fishermen of Saint John's River seine them in the grass along the shores at a depth of three or four feet. Mr. Stearns writes, speaking of the eastern part of the Gulf of Mexico: "They are found mostly in the bays and bayous where the bottom is muddy or grassy, but it is not unusual to find them in shoal water along the sand beaches of the coast and bays. Very shoal water seems to be particularly attractive, and they are often found at the water's edge embedded in the sand, with only their eyes in view. When alarmed or in pursuit of prey their movements are very swift, and the quickness with which they bury themselves in the sand is quite wonderful."

Their habit of ascending Southern rivers is remarkable. They are said to occur in Lake George and the other lakes at the headwaters of the Saint John's and the Ocklawaha Rivers. At Jacksonville they are commonly taken in company with bream, black bass, and other fresh-water fish, in winter as well as summer.

Although present in the shoal waters of Florida throughout the year, Mr. Stearns states that they are most abundant in summer. On the Connecticut coast, however, their habit of migrating seaward is much more pronounced. The Noank fishermen never find them until May. They say that they never catch them until after they have fished awhile for sea-bass. As early as the first of October they begin to grow scarce, and none are ordinarily caught after the middle of the month. I cannot find that they have ever been seen moving in schools, though fish taken in the same locality at the same time are usually quite uniform in size. They shift their position, probably in search of food, and where any are found they are plenty. This indicates that they are gregarious in habit: the abundance of food in special localities sufficiently explains this fact.

The Plaice feed upon small fish, shrimps, crabs and hermit crabs, squid, small species of shell-bearing mollusks, and certain radiates, such as sand-dollars. They are frequently seen at the surface, rapidly swimming, and even jumping out of the water, in pursuit of schools of sand-eels and sand-smelts. They also feed upon dead fish thrown out from the fish-houses. Little is known of their breeding habits. All the large females observed in July and August, 1874, upon the Connecticut coast contained spawn, but this was, evidently, far from maturity. The Fish Commission has obtained no very small specimens; in fact, none less than eight or nine inches in length, though the fishermen speak of capturing six-inch individuals. Their average length is from sixteen to thirty inches, and the weight about two and a half pounds, though it is not unusual to take individuals weighing seven or eight pounds. At Noank about eighty fish are ordinarily packed in a barrel, weighing from 160 to 175 pounds. The largest ever brought to Noank weighed twenty-six pounds. Others, of whose capture I have informed, weighed twenty, seventeen and a half, and fifteen pounds. In Florida and at Provincetown I have seen them three feet in length. A one-pound fish measures about fifteen inches; a one and a quarter pound fish, sixteen or seventeen; a two-pound fish, seventeen or eighteen; a three-pound fish, about twenty; a four-pound fish, about twenty-two; an eight-pound fish, about twenty-seven, and a ten-pound fish, about thirty inches. These proportions are taken from notes relating to a large number weighed and measured at Noank, Connecticut. The Winter Flounder or Flat Fish spawns in late winter and early spring near the shore, and it is possible that the Plaice breeds at about the same period.

The most extensive fishery for the Plaice is in the waters of Southern New England. Favorite fishing grounds are on sandy bottoms, at a depth of ten to twenty fathoms, along the Atlantic side of Block Island, Martha's Vineyard, and Eastern Long Island, where they are most plentiful. They are obtained in smaller numbers in the harbors and bays along the south shore of New England, on Shagwam and Middle Ground Reefs, in Fisher's Island Sound and Long Island

Sound, and outside of Fisher's Island. They are also taken in considerable numbers in the pounds of this region, occasionally five or six hundred at a time. The quantity taken in the weirs of New England in 1876 was estimated as follows:

	Pounds.
Weirs on north side of Cape Cod	436
Weirs on south side of Cape Cod	36,000
Weirs in Vineyard Sound	326,620
Weirs in Buzzard's Bay	15,749
Weirs on Block Island, estimated	94,500
Weirs in Fisher's Island Sound, estimated	4,000
Weirs on east end of Long Island	14,000
Traps in Rhode Island	172,250
	663,555
From other localities	50,000
	713,555
Estimated annual catch of Flat Fish	600,000
	1,313,555

Value of the above, at four cents a pound, $52,542.

These statistics of the catch in pound-nets include Plaice and Flat Fish, and in the statement of the total catch no distinction will be made between these two species.

Immense numbers of them are sometimes taken in large seines hauled up on the beach. In 1876 E. Cleveland seined 128,000 pounds at Menemsha Bight, Massachusetts. By far the greater quantity, however, is taken by small fishing smacks belonging to and hailing from Noank, Mystic, and New London, which pursue this special business from May until October. These vessels are usually absent from port four or five days, and spend two days in fishing. The fish are shipped in ice from Noank and New London principally to New York, and also to inland cities in the vicinity. A single smack, with a crew of a man and two boys, usually will obtain and ship to New York, on an average, about 12 barrels a week, about 160 barrels a year, or 25,000 to 28,000 pounds. Captain Palmer, of Noank, in 1873, caught on one trip of two days about 1,000 fish, weighing, perhaps, 2,000 pounds. On this trip he used four lines. A good fisherman is able to manage two lines, each carrying two hooks. Menhaden bait is always used by professional fishermen, though I have caught Plaice to good advantage with lobster bait. A vessel usually consumes one barrel of menhaden on each trip. The fish strike the hook sharply as soon as it approaches the bottom, giving little opportunity to the skates, which very seldom get a chance at a Plaice's hook. In this respect they are very different from the cod. When the fish have been hauled to the surface, they are quickly transferred, with as little injury as possible, to the well of the smack, which is amply large enough to hold a product of two or three days' fishing. They are thus brought alive to the place of shipment and reach the markets in excellent condition, a fact which partially explains their popularity compared with that of other fish of the same family.

In 1877 there were seven smacks engaged in this fishery—one from Mystic, one from New London, and five from Noank. It was estimated by the owner of one of these vessels that each vessel made on an average fifteen trips during the summer, and that each trip averaged 800 fish, weighing 1¾ pounds each, making a total of 1,400 pounds to a trip, or 21,000 pounds to the season, thus giving an aggregate of 147,000 pounds as the result of this branch of the fishery.

Captain Atwood states that in 1846 he began catching Plaice for the Boston market, in Provincetown Harbor, anchoring where the keel of the smack would just clear the bottom, and anywhere near Race Point he could catch them in great numbers, the largest weighing from ten to fifteen pounds each. In one afternoon he caught two thousand pounds. These he carried to Boston in the

well of his smack and tried to sell, but was unsuccessful, though they were offered under the name of Turbot, local prejudice being against them. In 1879 there were seven or eight boats engaged in the plaice fishery during the month of June, this month being the best for plaice fishing. In the latter part of July, when I made my observations, all of the winter boats had quitted for the year.

The method in use here is somewhat peculiar, and merits description. The fishermen call it "drailing for Plaice." The boat used is an ordinary cat-boat, managed by one person, and is allowed to drift with free sheet before the wind, while the fisherman stands in the stern dragging the line over the bottom, baited with a bit of squid or clam. The boat is kept as nearly as possible over the places where the flats are deepening most abruptly into the basin of the harbor, and where the water is from eight to eighteen fathoms deep. Only very large fish, weighing ten, fifteen, sometimes even twenty pounds, are taken in this manner. The average catch is from eight to twenty a day. In one day one man reported eight, one fourteen, one twenty-three. Some of these fish are sold in Provincetown, but the greater portion is sent iced to New York, where a price of twelve cents a pound, wholesale, is easily obtained. In Boston there is no market for them.

On the coast of New Jersey Professor Baird states that in 1854 they were taken in large numbers, by means of nets, in the deep slues along the beach. Along the southern coast they are occasionally taken by the line fishermen, and a considerable quantity is seined by the river fishermen. In the Gulf of Mexico they are rarely taken by hook and line, and are usually speared or jigged at night, by torchlight.

The Plaice has always been the most popular of our in-shore flat fishes, being exempt in a certain degree from the prejudice attaching to the fishes of this family. It seems to have been a common food-fish in South Carolina as early as 1760, and Schoepf mentions it as one of the food-fishes of New York in 1776. In 1856, according to Gill, it was found in the New York market in autumn, but seems to have been less in favor than the Flat Fish. At present the Plaice is growing in favor in New York, and is upon the lists of all good restaurants, though perhaps not so generally consumed as the Flat Fish, which comes in the winter, when the market is less lavishly supplied.

In Boston, and indeed throughout the greater part of New England, this, with all other Flounders, is considered unfit to eat, and it is by no means generally popular along the Southern coast, though in Florida its flesh is highly prized. The Connecticut fishermen esteem it greatly, and when preparing it for their own use are accustomed to hang it in the open air for a day or two "to dry," as they say. The wholesale price in New York varies from one and a half to six cents, but is usually three cents a pound.

Another species of Flounder, closely related to the Plaice, is the common Four-spotted Flounder, *Paralichthys oblongus*, which occasionally finds its way to market in company with the Plaice, and is doubtless sold under the same name. It is a small species, rarely attaining a greater length than twelve inches and a weight of one pound. It may be readily distinguished by the presence upon the back of four large, dark spots, elliptical in form, but these soon fade out after death.

Its distribution is much more restricted than that of the Plaice; it is most abundant, at a depth of ten to forty fathoms, off the southern coast of New England; it rarely occurs north of Cape Cod, though one individual was taken by the Fish Commission at the mouth of Salem Harbor, nor has it been recorded south of New York. There are two smaller species upon the Southern coast—one, *Paralichthys quadrocellatus*, broader than *Paralichthys oblongus*, also marked with four dorsal spots, and known in the South as the Four-spotted Flounder. This species has been observed as far north as Charleston and Fort Macon, while its western record of limit is Pensacola. Stearns records it as common from Cedar Keys south to Key West, and pronounces it an excellent food-fish.

It cannot at present, however, be considered very important. The other species, *Paralichthys stigmatias*, occurs in deep water (seventy-five fathoms) off the coast of South Carolina, and may be distinguished by the presence of three conspicuous spots upon the upper side of the body.

57. THE BASTARD HALIBUT.

This fish (*Paralichthys maculosus* Girard), writes Jordan, is known as the Halibut, Bastard Halibut, and Monterey Halibut. South of San Francisco, where the true Halibut is not found, the larger individuals, which really greatly resemble the Halibut, are known by that name, the young being rarely distinguished from other "Soles." At San Francisco, where the true Halibut is known, this species is called the Bastard Halibut, and sometimes the Monterey Halibut, as they are mostly brought from Monterey. It reaches a length of three feet and a weight of sixty pounds; the largest seen by us weighing fifty-five pounds. A great majority of those taken weigh less than three pounds, and it is said that large individuals are much less plenty than they formerly were. Its range is from Tomales Bay to San Diego, and south of Point Concepcion. It is the commonest species of its family. Although not rare at San Francisco, it forms no more than four per cent. of the entire flounder catch. It lives in rather shallow water, the young abounding close to shore, large ones being taken in the gill-nets. Large ones are more abundant at Monterey than farther south. It feeds upon fishes and crustacea, and in its habits seems very similar to the Eastern *P. dentatus*. It spawns in early summer, like other large fishes. It is subject to the attacks of the Hag Fish, *Bdellostoma Dombeyi*.

As a food-fish, it does not rank very high, the large specimens being tough and coarse compared to the Halibut, while the young are inferior to most of the species termed "Sole."

58. THE FLAT FISH, OR WINTER FLOUNDER.

Next in importance to the Plaice comes the Flat Fish, *Pseudopleuronectes americanus*, or Common Flounder, sometimes called the "Winter Flounder," said to be known in Massachusetts Bay as Mud-dab, and occasionally to be sold in New York under the name of Sole. This fish, like the Plaice, belongs to a genus unknown to Europe, but is closely related to the common Flounder, or Fluke, of the British coast. Its range is somewhat extensive, and in a certain degree it replaces the Plaice along our northern coast. It has not been observed south of Chesapeake Bay, but northward is common in the Bay of Fundy, on the eastern shores of Nova Scotia, and in the Gulf of Saint Lawrence, and, as far as observations have been made, upon the coast of Labrador.

Storer, writing in 1849, remarks: "It is probably the most common Flounder on the southwest coast of Labrador; we met with it first, though but sparingly, at the Saint Mary's Island, and observed it as far easterly as Bras d'Or, where it is to be found in immense numbers, the bottom being almost alive with them, and of large size."

Flat Fish are always upon the bottom, feeding chiefly upon minute shells, such as *Nucula* and *Bulla*, upon young crabs, or whatever they can find among the stones in the mud. Their mouths are very small, and since they would be unable to seize and kill other fish, they never come to the surface in pursuit of prey, as do the large-mouthed Flounders. They prefer sheltered bays and harbors, and appear to be equally abundant on the bottoms of the sand, mud, or rock; when at rest, they are usually partially embedded in the mud or sand at the bottom. I have observed that, when they come to a stop, they always settle themselves by convulsive motions of the fins and body, which has the effect of pushing them down into the soft bottom. This species is probably a more permanent resident of the localities which it inhabits than any other on our coast,

unless it be the sculpins. There is very little evidence of a tendency to move to and from the shore with a change of season. Winter and summer, they appear to be equally abundant from New York to the Bay of Chaleur, where, in the tide-way of Miramichi River, they are caught in winter through holes in the ice. In Labrador they are described as exceedingly abundant in summer, but nothing is known of their winter habits. Professor Baird found them scarce in Southern New Jersey in summer, but learned that they were very abundant in the bays in winter. Small quantities are brought to Washington in winter from the mouth of the Chesapeake.

The spawning season occurs early in spring, in February and March on the Connecticut coast, and is thought to be closed by the first part of April. Young fish of half an inch in length are found in July in the deeper parts of the bays and sounds, and in August and September, having attained the length of one and one-half to five inches, occur in great abundance in the coves and along the sandy shores of the Southern New England coast, in very shallow water. Their growth is probably rapid, though it would seem most likely that the five-inch specimens, just referred to, were eighteen months rather than six months old. The largest that have been discovered were fifteen inches long, and would weigh from one to one and a half pounds.

The flesh of the Flat Fish is solid, white, and of excellent flavor, and deserves a more general popularity than it has yet attained. It is, and has been for the last century, largely consumed in New York in winter. Schoepf, writing in 1776, mentions it as occurring in the market in spring; later, writing in 1818, he states that small numbers were found in the stalls in January and February, taken with spears while searching for eels. These were not very inviting, owing to their mangled appearance and frozen state, but, with the disappearance of ice and the approach of spring, their numbers increased, and in March the stalls were well filled with them, cheap and fresh and good. They were only used as pan-fish. Gill wrote, in 1856: "This is the most common species of flounder that is brought to the city markets in the winter and spring months; it is seldom sold at a higher price than eight to ten cents per pound. Flounders are chiefly sold by the weight; occasionally they are strung through the branchial apertures on twigs and nominally sold by the bunch."

The Smooth Flounder, or Christmas Flounder, *Pleuronectes glaber*, is very similar in habits and appearance to the Flat Fish, and is still closer to the Flounder of Europe, being a member of the same genus. It may be distinguished from the former by its smooth skin, which has given to the species, in some localities, the name "Eel-back." Its distribution is extremely limited, it having been recorded as only found in Salem, Massachusetts, Portland and Belfast, Maine, or within the limits of two degrees of latitude. Its range may in the future be extended farther to the north, but it is certain that at present none occur south of Salem. In Casco Bay they are very abundant in summer, and the Fish Commission secured great quantities of them in water three or four fathoms deep in Bluelight Cove. They have never elsewhere been observed, except in winter, about Christmas time, when they come into the harbors to spawn. At Salem they are, on this account, called the Christmas Fish. Considerable quantities are caught every year by spearing them upon the sand. At this place they are also called "Fool Fish," because, in their anxiety for food, they will bite at any kind of bait, even at a rag. The spawning season is short, and they soon retire into deeper water. At Portland, and in the vicinity, considerable numbers are taken in the winter fishery in company with the Flat Fish, and with them are sent to New York and neighboring markets. In one instance a quantity was offered for sale in the markets of Washington. The spawning season on the coast of Maine is slightly earlier than that of Massachusetts, beginning as early as the middle of December, while in Penobscot Bay they are taken at the very beginning of the month, full of spawn. In Penobscot Bay they are taken in traps, or "fliers," as the fishermen call them, shaped

something like lobster-traps and baited. The young Smooth Flounder may be taken in summer on the beaches. The largest females observed weighed twenty-three ounces, the weight of the spawn being seven ounces. Too little attention has hitherto been paid to this fish, but it seems more than probable that in the future it will greatly increase in favor.

59. THE FLAT FISHES AND SOLES OF THE PACIFIC COAST.

By DAVID S. JORDAN.

THE STARRY FLOUNDER—PLEURONECTES STELLATUS Pallas.

This species is known, wherever found, as the "Flounder," all others being considered as Bastard or False Flounders. At San Francisco the name Flounder is rarely used in a generic sense, but only as a special appellation of this species. It reaches a length of nearly three feet, and a weight of fifteen to twenty pounds, larger individuals being found northward than southward along the coast. The average length in the market is about fifteen inches, and the weight two or three pounds. Its rate of growth is probably rapid, but we have no certain data in regard to it.

It ranges from San Luis Obispo to Kamtchatka, and from San Francisco northward it is by far the most abundant species. It probably constitutes half, by weight, of the total annual catch of Flounders on the Pacific coast. It enters the mouths of rivers, and considerable numbers are taken in the salmon-nets on the Lower Columbia. It is found in water of moderate depth, and is taken in seines and gill-nets, and sometimes with the hook.

Its food is crustacea, mollusca, and such fishes as it can swallow, its mouth being comparatively small. It spawns in summer. Nothing special is known of its breeding habits. It has no especial enemy that we know of, with the exception of a tetradecapod, known as "fish-louse," which is very frequently found attached to the fins, gill-membranes, and gills of this and other species of flounders.

As a food-fish this species is held in rather high esteem. The flesh is firm, and although coarser than in the so-called Soles, is of fair flavor in the young. The very large individuals (eight to twenty pounds) are sold at a lower price, and are considered poor eating. A considerable portion of those in the San Francisco market come from Humboldt Bay.

This, according to Dr. Bean, is one of the most widely distributed littoral fish known to exist, ranging in North America to the mouth of the Colville and Anderson Rivers on the arctic coast. It enters extensively into the resources of Alaska, being the largest and most abundant of its kind in that region.

A related species, *P. glacialis*, is especially abundant in Northern Alaska, occurring plentifully as far south as Saint Michael's. Although small, its great abundance and fine flavor make it important as an article of food. Traveling parties of Eskimos generally have a supply of this fish in their bidarras. They are usually eaten raw.

THE ROUGH LIMANDA—LIMANDA ASPERA (Pallas) Bean.

This species, according to Dr. Bean, is smaller than its Atlantic relative, *Limanda ferruginea*, which it closely resembles, and its range is rather limited. It is found about Unalashka and has been taken at Sitka, Wrangel, and other localities in the Gulf of Alaska. Its flavor is fine, and it is used extensively for food by Eskimos and Indians.

THE DIAMOND FLOUNDER.—HYPSOPSETTA GUTTULATA (Girard) Gill.

In the neighborhood of San Francisco this species is known as the "Turbot," many of the dealers stoutly averring that it is identical with the English fish of that name. South of Point Concepcion the name Diamond Flounder is in use. This refers to the rhombic form of the fish, and the name seems an appropriate one. It reaches a length of eighteen inches and a weight of four pounds, but as usually seen in the market its length is about one foot.

The geographic range of this species seems to be from Cape Mendocino to Magdalena Bay. It seems to be more plentiful in the bays of Tomales and San Diego than elsewhere, apparently preferring shallow water and sandy bottoms. It is one of the more abundant species, forming perhaps two per cent. of the catch of Flounders in the neighborhood of San Francisco.

Its food consists mainly of crustacea and small mollusks. Nothing special is known of its breeding habits. Its enemies are those of all Flounders, and no diseases have been noticed. As a food-fish it ranks high. It is one of the most firm-fleshed of the Flounders.

THE "SOLES" OF CALIFORNIA.

LEPIDOPSETTA BILINEATA (Ayres) Gill.

This species has no other distinctive name than "Sole." It reaches a length of twenty inches and a weight of five or six pounds. Its average weight in the market is about three pounds. It ranges from Monterey to Alaska, and its relative abundance steadily increases as we go northward from Monterey to Vancouver's Island. In Puget Sound it makes about thirty per cent. of the flounder catch; about San Francisco barely two per cent. It lives in rocky places in deep water, and most of those taken about San Francisco come from the neighborhood of the Farallones. It takes the hook more readily than any of the other small-mouthed Flounders, and considerable numbers are taken by the Chinese on their set-lines, especially at Monterey. They feed chiefly on crustaceans and small fishes.

Nothing special is known of its breeding habits, and nothing distinctive of enemies or diseases. It is perhaps more subject to the parasitism of the fish-louse than any of the other species.

Dr. Bean found this fish abundant in Alaska, and one of the most important of the flat fishes in that territory. It is there regarded as an excellent food-fish. The natives spear it as it lies entirely concealed in the loose sand along shore, where it comes at eventide to feed on small crustaceans.

PAROPHRYS ISCHYRUS Jordan and Gilbert.

Four specimens only of this species have been seen. These were taken with a seine at Seattle. It resembles the preceding in appearance, and probably in habits. Those seen were about eighteen inches long, and weighed about three pounds.

"This is a coarse, rough fish in its general appearance, greatly resembling the Flounder, *Pleuronectes stellatus*, but differing from it in the ctenoid scales, and in the presence of an accessory lateral line, characters in which it agrees with the next species. It has hitherto been found only in Puget Sound, and reaches a length of about eighteen inches."—*Lockington*.

PAROPHRYS VETULUS Girard.

This species is always called Sole by the fishermen. It is one of the smallest species, reaching a length of about fourteen inches and a weight of about two pounds. Those usually seen in

market average less than half a pound. It is found from Santa Barbara to Alaska, and from San Francisco northward is extremely abundant. In number of individuals taken, this species is exceeded only by *Pleuronectes stellatus*. In number of pounds it probably ranks below *Hippoglossoides Jordani*. It forms about one-fifth the whole flounder catch of the coast. It lives near the shore, and is taken in gill-nets and seines. It feeds on crustacea and the like. As a food-fish it meets with a ready sale, but its flesh is rather poor and tasteless. It spawns in spring. Nothing further is known of its breeding habits, and nothing of its enemies or diseases. It is often found in the stomachs of larger predaceous fishes.

Its flesh is softer than that of other Flounders, and it does not make an attractive appearance in the market. It always readily sells, however, and the quality of the flesh is probably better *than that of some of the other kinds.*

PAROPHRYS ISOLEPIS (Lockington) Jordan and Gilbert.

This species, too, is a Sole to the fishermen. It reaches a length of about fifteen inches and a weight of about two and a half pounds. Its usual length is about ten inches, with a weight of half a pound. It ranges from Monterey to Puget Sound, inhabiting rather deep water and becoming larger in size and more plentiful northward. About San Francisco it is mainly taken by the paranzelle fishermen, who obtain it in great numbers, but it forms less than one per cent. of the flounder catch of the coast. Its food is mainly crustacea and mollusks. It spawns in spring, at which season the largest catches of it are made.

Large specimens of this species are sold with the best Soles (*Psettichthys*), which they greatly resemble. Small ones rank with *Glyptocephalus pacificus* and the like, and often cannot be sold.

CITHARICHTHYS SORDIDUS (Girard) Gthr.

This species is often known as the "Plaice" in Puget Sound. About San Francisco it becomes, like the others, a "Sole." It is one of the smallest species, reaching a length of fifteen inches, and a weight of two pounds. Its average weight in market is little more than half a pound. It ranges from San Diego to Puget Sound, being rare south of Point Concepcion, and most abundant about Monterey. It lives in comparatively deep water, and is considered distinctively a deep-water species by the fishermen in Puget Sound. It takes the hook very readily, and great numbers are taken on set-lines by the Chinese, to dry for market. It probably makes about eight per cent. of the entire flounder catch of the coast. It feeds on small fishes, the anchovy being one of its special articles of food.

PSETTICHTHYS MELANOSTICTUS Girard.

This species is everywhere a Sole, and at San Francisco it is considered to have a better claim to that title than any other species. It reaches a length of about twenty inches, and a weight of four or five pounds. Its average length is about fifteen inches. It ranges from Monterey to Wrangel, Alaska. It lives at no great depths, and is about equally abundant the entire length of the coast. Although never found in large numbers, it is always present in the markets, and forms some five per cent. of the entire flounder catch of the coast. It feeds upon fishes and crustacea.

Nothing special is known of its breeding habits, enemies, or diseases. As a food-fish it is considered the best of the family by those who distinguish it from related species.

HIPPOGLOSSOIDES JORDANI Lockington.

This species is known universally as the "Sole." I have also heard the Italian name "Soglia" applied to it more often than to related species. It reaches a length of eighteen inches, and a weight of six or eight pounds, the average being about three. It ranges from Monterey to Puget Sound, being comparatively scarce north of Cape Mendocino, but in Monterey Bay the commonest species, and forming probably fifteen per cent. of the Flounders in the market of San Francisco. Great numbers are taken by Chinamen on set-lines baited with anchovies. It lives in water of no great depth. It feeds upon anchovies, shrimps, and all sorts of small fishes and crustacea. It spawns in early summer. Nothing especial is known of its breeding habits. Its enemies and diseases are similar to those of other Flounders.

It is one of the best of the Flounders as a food-fish. Great numbers are dried yearly by the Chinese, who suspend them by strings on a frame placed on the roofs of the houses, as they are too fleshy to dry well on tables. Here they rustle in the wind, and, striking together, produce a sound like the wind among the leaves.

"It appears strange," remarks Lockington, "that this common species should have escaped the notice of naturalists until last year. In the markets of San Francisco it abounds throughout every month of the year, and in Monterey Bay it is the most abundant of its tribe. Professor Jordan informs me that about five hundred pounds' weight of this fish are taken daily at Monterey alone by the Chinese, besides large quantities taken by the Italians. An examination of the stock in trade of the Chinese located near Monterey, proved that over nineteen-twentieths of the fish that dry on hurdles and flap in the wind around the hovels consisted of this fish; a few sharks, with *Psettichthys melanostictus* and *Citharichthys sordidus*, constituting the remainder."[1]

It occasionally reaches sixteen inches or more in length and a weight of five pounds, and is considered one of the best of its tribe, but is inferior to the Black-dotted Flounder, the Turbot, and one or two others. It becomes rare northward, yet occurs in Puget Sound; south of Monterey it is not on record.

HIPPOGLOSSOIDES EXILIS Jordan and Gilbert.

This species is one of the smallest, reaching a length of about nine inches, and a weight of less than a pound. It inhabits deep waters on sandy bottoms from San Francisco to Puget Sound. It is taken in the sweep-nets of the paranzelle in spring off Point Reyes in enormous numbers, sometimes nearly a ton at a time. In Puget Sound it is less common, although frequently taken in seines. It has not been noticed by naturalists until the present year, and has probably been rarely taken until the introduction of the paranzelle. It feeds on small fishes, crustaceans, etc. It spawns in spring, perhaps coming from still deeper water, as in the winter none were noticed in the markets. Its enemies and diseases are unknown. Most of those taken by the paranzelle are thrown overboard. The flesh is soft, and the fish does not sell for enough to pay for bringing it in.

This species is readily distinguished from the preceding by its much more slender form, and by the large size of the scales, which are very delicately ciliate on their hinder edge. The eyes are very large, their longitudinal diameter contained about three and one-third times in the length of the head. The greatest depth is contained about three and a half times in the total length.

In July it was tolerably common in the markets of San Francisco, and its previous rarity is probably occasioned by the fact that it is only taken in tolerably deep water, and is too small to be considered of much value.

[1] Report, Commissioner of Fisheries State of California, 1880, p. 25.

The specimens I have seen were from eight to ten inches in length, and three-quarters of a pound in weight. It occurs in Puget Sound, but is not very common.

HIPPOGLOSSOIDES ELASSODON Jordan and Gilbert.

This species reaches a length of about fifteen inches, and a weight of two or three pounds at least. It has been found in Puget Sound, in rather deep water about the wharves of Seattle, Washington Territory, and New Tacoma. It takes the hook very readily, and affords the boys considerable amusement. Its value as food is probably similar to that of *H. Jordani*.

Dr. Bean states that he has specimens from Kodiak, Unalashka, and the Shumagin Islands, Alaska. It is a food-fish of some importance in these localities.

XYSTREURYS LIOLEPIS Jordan and Gilbert.

This species reaches a length of fourteen inches and a weight of two pounds; ranges from Point Concepcion southward. It lives in water of moderate depth, usually about the kelp. It takes the hook readily, spawns in spring, and feeds on crustacea and small fish. It is too scarce to have any special economic value.

ATHERESTHES STOMIAS Jordan and Gilbert.

This species, so far as known, does not exceed eighteen inches in length and one and a half pounds in weight. It is perhaps the slenderest Flounder known. It has only been seen among fishes taken in the sweep-nets of the paranzelle off Point Reyes, and only about a dozen specimens are known. It probably inhabits considerable depths, and will doubtless be found to belong to the Alaskan fauna.

THE SLIPPERY SOLE—GLYPTOCEPHALUS PACIFICUS Lockington.

Like various other species, this fish is known as the Sole, wherever found. It reaches a length of fifteen inches and a weight of two pounds. As usually seen in the market, it is about eight inches in length and weighs about half a pound. It inhabits deep or cold waters, and ranges from Monterey to Vancouver's Island. In California it is only taken in deep water, and is therefore rarely brought in except by the paranzelle, who obtain it sometimes in enormous numbers. In Puget Sound it comes nearer shore, and is often taken in the seines. It has been brought into the San Francisco market only since the establishment of the paranzelle fishing a few years ago. Since then, it has rapidly increased in abundance in the market, and now makes about five per cent. of the Flounders sold in San Francisco. Many pounds of small ones are daily thrown away in the spring and summer. It feeds on crustacea and the like.

It spawns in May and June, and probably then comes into shallow water, as the catch is then greater than in winter. The large ones are considered among the best of the Flounders. The small ones are little valued. The whole body is excessively slimy when out of water, more so than in any other Flounder.

THE LONG-FINNED SOLE—GLYPTOCEPHALUS ZACHIRUS Lockington.

This species is likewise known as a Sole, but occasionally distinguished as long-finned. It reaches a length of eighteen inches and a weight of about two pounds. The average length is more than a foot. It has been thus far noticed only in deep water about San Francisco and Monterey. It is one of the least abundant of the Flounders, rarely more than a dozen coming into the San Francisco market in a week, and often for long periods none at all. Until the introduction of the paranzelle, it was unknown at San Francisco.

In respect to food, breeding habits, and localities, it agrees entirely with *G. pacificus* so far as we know. Its skin is not slimy, and its flesh is very firm and white, and said to be of very superior flavor, similar to that of the European Sole.

"Up to the present time," says Lockington, "this species is only known from the markets of San Francisco, to which it is brought from deep water near Point Reyes, some thirty miles north of the city. It is comparatively rare; seldom more than three or four are offered for sale on any one day, and it is not brought in at all in the winter. It attains a length of eighteen inches, and a weight of about two pounds, and is held in high esteem. Hitherto it is only known to occur in Monterey Bay and in the vicinity of San Francisco. As its mouth is too small for the hook, and its habitat too deep for the gill-nets, it is taken chiefly in sweep-nets."

The three following species are very similar in size, appearance, habits, and value, and the same remarks, except in regard to distribution, will apply to them all:

PLEURONICHTHYS VERTICALIS Jordan and Gilbert.

PLEURONICHTHYS QUADRITUBERCULATUS (Pallas) Lockington.

PLEURONICHTHYS CŒNOSUS Girard.

These three species have no distinctive popular names, the fishermen confounding them with various other species under the name of Turbot and Sole.

As usually seen in the markets, these species average about ten inches in length, *P. verticalis* being usually the smallest of the three, and *P. quadrituberculatus* the largest; all, however, reach sometimes a length of fifteen inches and a weight of two or three pounds.

P. quadrituberculatus and *P. verticalis* have been thus far noticed only in Monterey Bay and about Point Reyes and the Farallones. *P. cœnosus* is found from San Diego to the Aleutian Islands, and is especially abundant in rocky coves about Puget Sound. All three of them are now migratory and live in considerable depths of water, being rarely taken near shore except in the spawning time.

Compared with other Flounders, none of these are ever abundant. Fifteen individuals of the three species together would be a large proportion in one haul of the gill-net in Monterey Bay, in the season of their spawning. At other times they rarely come near enough to shore to enter a gill-net.

Unlike the other Flounders, these three species feed chiefly or entirely on plants; the stomach and intestines are always full of algæ, and, although they occasionally take the hook, animal food makes a small portion of their diet.

These species spawn in the spring, chiefly in May and June. Nothing is known of their breeding habits, further than that they are taken in the gill-nets and in the sweep-nets of the paranzelle in greater numbers at that season than earlier in the year, and they probably spawn in sandy places, and otherwise live among the rocks.

No special enemies are known, other than predatory fish, and no diseases have been observed. As food-fish, they are not distinguished from related species.

60. THE HALIBUT—HIPPOGLOSSUS VULGARIS.

The Halibut, *Hippoglossus vulgaris*, is widely distributed through the North Atlantic and North Pacific, both near the shores, in shallow water, and upon the off-shore banks and the edges of the continental slope down to a depth of two hundred to two hundred and fifty fathoms or more. In the Western Atlantic the species has not been observed south of the fortieth parallel, stragglers

having occasionally been taken off Sandy Hook, Block Island, and Montauk Point, while it ranges north at least to Cumberland Gulf, latitude 64°, and to Holsteinborg Bank in Davis Strait, and as far as Disko and Omenak Fiord, latitude 71°, on the coast of Greenland, five or six degrees within the Arctic Circle. Along the entire west coast of Greenland they exist, abundant about Iceland and north to Spitzbergen, in latitude 80°. No one knows to what extent they are distributed along the European and Asiatic shores of the Arctic Ocean, but they have been observed on both sides of the North Cape, in East and West Denmark, and from the North Cape, latitude 71°, south along the entire western line of the Scandinavian Peninsula, in the Skager Rack and Cattegat, but not, however, so far as I can learn, in the Baltic. Halibut are occasionally seen in the southern part of the North Sea and in the English Channel: south of latitude 50° their range in the Eastern Atlantic appears to cease. There is yet some question whether it is found in Southern Ireland, but some of the largest individuals recorded from Great Britain were taken in the Irish Sea, off the Isle of Man.

On the Pacific coast the Halibut, which has been shown by Dr. Bean to be identical with that of the Atlantic, ranges from the Farallone Islands northward to Bering Straits, becoming more abundant northward. "Its center of abundance," says Bean, "is in the Gulf of Alaska, particularly about Kodiak, the Alexander Archipelago, and the Shumagins. Large halibut are numerous about the Seal Islands, but the small ones have been killed by the seals. I have heard from good authority of their capture as far north as Saint Lawrence Bay, near East Cape, in Siberia. It has several times been reported from off the heads of Marcus Bay, Siberia." It is occasionally taken off San Francisco and about Humboldt Bay. In the Straits of Fuca and in the deeper channels about Puget Sound it is taken in considerable numbers.

A large halibut bank exists in the mouth of the Straits of Fuca, about nine miles from Cape Flattery in a northwesterly direction, and their capture is an important industry to the Coast Indians.

The Halibut is emphatically a cold-water species. That it ranges nine or ten degrees farther south on the American than on the European coast, is quite in accordance with the general law of the distribution of fish-life in the Atlantic; indeed, it is only in winter that Halibut are known to approach the shore to the south of Cape Cod, and it is safe to say that the temperature of the water in which they are at present most frequently taken is never, or rarely, higher than 45°, and seldom higher than 35°, and often in the neighborhood of 32°. Its geographic range corresponds closely to that of the codfish, with which it is almost invariably associated, though the cod is less dependent upon the presence of very cold water, and in the Western Atlantic is found four or five degrees—in the Eastern Atlantic at least two—nearer the Equator, while the range of the two species to the north is probably, though not certainly, known to be limited relatively in about the same degree. In the same manner the Halibut appears to extend its wanderings further out to sea, and in deeper and colder water than the cod. Although observations on this point have necessarily been imperfect, it seems to be a fact that, while cod are very rarely found upon the edge of the continental slope of North America, beyond the 250-fathom line, Halibut are present there in abundance.

COMMON NAMES.—The name of this species is quite uniform in the regions where it is known, though, of course, subject to certain variations in the languages of the different countries, and its characteristic features are so unmistakable that it is rarely confounded with other species, the only fish for which it is ever mistaken seeming to be the Turbot of the European coast, with which it sometimes interchanges names. In Scotland it is said that the Halibut is frequently called the Turbot, and Yarrell has expressed the opinion that in instances where it had been

claimed that Halibut had been taken in the south of Ireland the Turbot was the species actually referred to.

"Halibut" and "Holibut" are words which are as old as the English language. In Germany it is called "Heilbutt" or "Heiligebutt"; in Sweden, "Hällefisk" or "Hälleflundra," while in Holland the name is "Heilbot."

In studying these names it should be borne in mind that "but" or "bott" is another word for a flounder or flat fish, and that the English, Dutch, German, and Scandinavian prefixes to either this word or the equivalent word Flounder are presumably of the same meaning. A false derivation has been imagined for the name, which is exemplified in the German word "Heiligebutt" just mentioned, and also in the English orthography, which is sometimes encountered "Holybut." This is without foundation, for the Halibut has never been mentioned more than any other species of flat fish, and the derivation is as fanciful as the New England one of "Haul-a-boat," which our fishermen have frequently assured me was the proper name, referring to the size and strength of the fish. The true derivation of the word is best understood by a study of its Scandinavian names, from which it appears that the prefix has reference simply to the holes or deep places at sea in which the fish is found, and that the name simply means "a deep-sea fish," or "a deep-sea flounder." The name "Flétan" which a species bears in France is not distinctive, the fish being almost unknown in that country.

DISTRIBUTION IN THE NORTHWESTERN ATLANTIC.—The general distribution of the Halibut having been sketched in outline, it seems appropriate to discuss more fully the range and abundance of the fish upon the coast of North America, where they are sought by American fishing vessels, and in this discussion some of the facts already briefly stated will necessarily be repeated in part or at length. Halibut are taken abundantly on Holsteinborg Bank, at the southern entrance to Davis Strait, latitude 67° north and longitude 54° to 56° west, where several Gloucester schooners have in past years obtained large cargoes of salted fish. In Etzel's "Grönland," the materials for which were largely derived from Rink's "Grönland geographisk og statistisk Beskrevet," published in 1857, the distribution of the species in this region is quite fully discussed. It is there stated that Halibut are taken chiefly in the southern part of North Greenland, and especially on the shoals among the islands in the district of Egedesminde, especially about Agto, Riskol, and Ikerasak, in latitude 68°, and somewhat less near Disko, in latitude 70°. They are captured most abundantly in the spring and fall, when the Greenlanders take many in these localities. They are even taken, at greater depths, as far north as Omenak, in latitude 71°. In a later work, however, Rink asserts that "the Netarnak or larger Halibut is found on the banks, as well as in different places outside the islands, up to 70° north latitude, in depths of from thirty to fifty fathoms."[1]

In the same later work Rink remarks that Halibut are plentiful in the fall about Egedesminde, especially about Agto, the southernmost outpost of North Greenland.[2]

Regarding the occurrence of Halibut in South Greenland, Etzel goes on to state that in July and August they are taken on the outer coast and among the islands at depths of thirty to fifty fathoms, while in winter they frequent deeper regions and are but seldom seen, chiefly on the cod-

[1] BROWN, ROBERT: Danish Greenland | its People and its Products | By | Henry Rink | Knight of the Order of Dannebrog | Director of the Royal Greenland Board of Trade | Formerly Inspector of South Greenland | Author of Tales and Traditions of the Eskimoes, etc | (Cut of medal.) | Edited by | Dr. Robert Brown, F. L. S. F. R. G. S. | Author of The Races of Mankind, etc | With Illustrations by the Eskimo, and a Map | Henry S. King & Co., London | 1877. 8vo, pp. xvii, 468, 16 plates, and a map on p. 1 (p. 134).

[2] RINK: *Op. cit.*, pp. 340, 341.

banks off Holsteinborg and in the sounds farther south.[1] Rink narrates that "in the year of the war," when the Europeans were obliged to supply themselves with provisions from Greenland, there were taken among the islands off Godthaab (64° 8′ north latitude) two thousand Halibut, and that in a single half day two boats took over one hundred. This was in 1809. They are rarely taken in the district of Julianshaab, in latitude 60° 43′ north.

Peter C. Sutherland, writing of Riskol Bank, in 1850, stated that Halibut were then very abundant in that locality, and that the cod-fishing vessels which visited Davis Strait every season use them to bait their hooks, though the supply far exceeded the demand for this purpose.[2]

On the return of the Penny Expedition, in 1851, Sutherland narrates that when crossing the Arctic Circle, in longitude 53°, the sailors put over lines baited with pork and hooked a cod and a Halibut at the depth of forty fathoms.[3]

The most northern occurrence of the Halibut on the western side of Davis Strait is that recorded by Mr. Ludwig Kumlien, naturalist of the Howgate expedition, who saw a large individual taken by the Eskimos off the mouth of Davis Strait, near latitude 64° north.

Richardson, in the "Fauna Boreali-Americana," speaks of the occurrence of the species on the Greenland coast, but seems to have no authentic information of its having been observed even as far north as Labrador on the opposite side.

There can be no reasonable doubt that Halibut are found along the entire eastern coast of Labrador, though there is no other published record of their occurrence north of Red Bay, in the Straits of Belle Isle, near latitude 51° 46′ north, where they were observed by Mr. Horatio R. Storer, several having been taken during his stay at that place in the summer of 1849.[4]

They are abundant in certain parts of the Gulf of Saint Lawrence, especially the island of Anticosti, and are also found along the entire coasts of Newfoundland and the eastern shores of Nova Scotia.

In June, 1878, the schooner "G. P. Whitman," of Gloucester, caught a fare of Halibut in two to twelve fathoms of water near Green Point, Newfoundland. The crew said that they could see the fish lying on the bottom in shallow water.

Capt. George Olsen, schooner "Proctor Brothers," arrived at Gloucester August 2, 1880, with 22,000 pounds' weight of fresh Halibut, from Anticosti. He reported Halibut plenty then at the western end of the island close inshore—within half a mile; he saw the Halibut sporting near and on the surface; he found they would not bite, as on the banks, at Halibut bait, and since fresh herring or capelin could not be obtained, could get only a partial trip of Halibut. They were good fish, weighing sixty to eighty pounds.[5]

According to M. H. Perley they are found in the Bay of Fundy up to its very head, where they are taken in summer in Cumberland Bay, near the light-house off Apple River, and also in West Bay. He states that they are also found on the south shore of the Bay of Fundy, and abundantly from Cape Split to Brier Island, as well as in the Annapolis Basin.[6]

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[1] ETZEL, ANTON VON: Grönland geographisch und statistisch beschrieben. Aus dänischen Quellschriften von Anton von Etzel. Stuttgart, J. G. Cotta'scher Verlag, 1860. 8vo, pp. xiv, 635 (p. 254).

[2] SUTHERLAND, PETER C.: Journal of a Voyage in Baffin's Bay and Barrow Straits in the years 1850–1851, performed by H. M. Ships "Lady Franklin" and "Sophia" . . . in search of the missing crews of H. M. Ships "Erebus" and "Terror." . . . By Peter C. Sutherland, M. D., M. R. C. S. E., Surgeon to the Expedition. In two volumes. . . . London: . . . 1852. (Vol. i, p. 26.)

[3] SUTHERLAND: *Op. cit.*, ii, p. 341.

[4] STORER, HORATIO ROBINSON: Observations on the Fisheries of the Coasts of Nova Scotia and Labrador, with Descriptions of New Species. <Proc. Bost. Soc. Nat. Hist., vi, 1857, pp. 247–270, pls. vii–viii (p. 267).

[5] Statement of A. Howard Clark.

[6] Reports on the Sea and River Fisheries of New Brunswick, 1852, pp. 159–163.

Perley's report was prepared in 1852, and there is no evidence of a diminution in that region since the time he wrote.

Mr. J. Matthew Jones tells me that Halibut are occasionally taken at Five Islands in the Basin of Minas, but that this is of rare occurrence.

I am indebted to Captain Ashby for the following facts about the southern limits of the distribution of the Halibut:

He has never known them to be found south of Sandy Hook, where large ones are occasionally taken in winter. In May, 1876, the schooner "Cartwright," fishing ten miles southeast of Montauk Point, caught many Halibut. In February, 1876, some Noank smacks caught a few Halibut about eight miles from land, off the southeast point of Block Island. Within the last forty years one or two Halibut have been taken off the outer shore of Fisher's Island. He has never known any to be taken in Long Island Sound. Halibut are sometimes taken in three fathoms of water among the breakers of Nantucket, in "blowy weather." Forty years ago they were abundant about Gay Head and Noman's Land. There has been no systematic fishing there lately, but some Halibut have probably been taken.

The local papers chronicled the capture, on May 1, 1876, off Watch Hill, Rhode Island, of an eighty-pound Halibut, the first taken in that vicinity for many years.

They are occasionally taken along the shores of Maine and Massachusetts, but so seldom that a capture of this kind by one of the inshore fishermen is always mentioned in the local papers.

ABUNDANCE.—Half a century ago Halibut were extremely abundant in Massachusetts Bay. Elsewhere in this essay are given several instances of their great plenty and voracity, as narrated by some of the early fishermen of Cape Ann. Of late years, however, few are found except in deep water on the off-shore banks.

The presence of so important a food-fish as the Halibut in America did not long escape the observations of the early English explorers. Capt. John Smith, in his "History of Virginia," wrote: "There is a large sized fish called Hallibut, or Turbut: some are taken so bigg that two men have much a doe to hall them into the boate; but there is such plenty, that the fisher men onely eate the heads & finnes, and throw away the bodies: such in Paris would yeeld 5. or 6. crownes a peece: and this is no discommodity."

SIZE.—The Halibut is surpassed in size by only three of our eastern species—the sword fish, the tunny, and the tarpum. There is said, by experienced fishermen, to be a great difference in the size of the two sexes, the females being much the larger; the male is said rarely to exceed fifty pounds in weight, and to be, ordinarily, in poor condition and less desirable for food. The average size of a full-grown female is somewhere between one hundred and one hundred and fifty pounds, though they are sometimes much heavier. Captain Collins, who has had many years' experience in the Gloucester halibut fishery, assures me that he has never seen one which would weigh over two hundred and fifty pounds, and that one weighing over two hundred and fifty pounds is considered large. There are, however, well-authenticated instances of their attaining greater dimensions. Captain Atwood, in communication with the Boston Society of Natural History, in 1864, stated that the largest he had ever taken weighed, when dressed, two hundred and thirty-seven pounds, and would probably have weighed three hundred pounds as taken from the water. In July, 1879, however, the same reliable observer saw at Provincetown two individuals taken near Race Point, one of which weighed three hundred and fifty-nine pounds (three hundred and two pounds when dressed), the other, four hundred and one pounds (three hundred and twenty-two pounds when dressed).

There is a tradition in Boston that Mr. Anthony Holbrook, one of the early fish-dealers of that city, had in his possession a Halibut, taken at New Ledge, sixty miles southeast of Portland, which weighed over six hundred pounds. This story, which is recorded by Storer in his "Fisheries of Massachusetts," Captain Atwood believes to be untrue. Halibut, weighing from *three to four hundred pounds, though unusual in comparison with the ordinary size, are by no* means rare. I have before me a record of ten or twelve such, captured on the New England coast during the past ten years. Nilsson, a Swedish ichthyologist, has mentioned the capture of a Halibut on that coast which weighed seven hundred and twenty pounds. There are stories of Halibut ten feet in length; a fish weighing three hundred and fifty pounds is between seven and eight feet long and nearly four feet in width. The largest individuals are not considered nearly so good for table use as those of less than one hundred pounds' weight. A fat female of eighty pounds is, by good judges, considered to be in the highest state of perfection. Males are not, however, so highly esteemed. Small Halibut, known as "Chicken Halibut," ranging from ten to twenty pounds, are much sought after by epicures, and bring a high price in the New York and Boston markets. They are comparatively rare, however, and a Halibut weighing ten pounds or less is rarely seen; the smallest recorded on our coast was about five inches in length and was taken by *Professor Verrill in a dredge-net in the Strait of Canso.*

The Halibut of the Pacific are apparently similar in dimensions to those of New England. Mr. Anderson, inspector of fisheries for British Columbia, states that they there attain a weight of 200 pounds.

The wholesale dealers of Gloucester, in buying fresh Halibut from the fishermen, recognize two grades; one, which they call "Grey Halibut," they consider to be of inferior value, and pay a lower price for. The Grey Halibut are distinguished by dark clondings or blotches upon the under side, which in the most remarkable fishes are pure white. Almost all the largest Halibut are classed among the Greys. Fishermen claim that there is no actual difference between the gray and the white fish, and it is a fair question whether they are not right.

MIGRATIONS.—It is useless to attempt to describe here the migrations of the Halibut from place to place; although much information has been received upon this subject, the problem requires long and careful study.

The history of the halibut fishery has been a peculiar one. At the beginning of the present century these fish were exceedingly abundant in Massachusetts Bay. From 1830 to 1850, and even later, they were extremely abundant on George's Banks; since 1850 they have partially *disappeared from this region, and the fishermen have since been following them to other banks,* and since 1874 out into deeper and deeper water, and the fisheries are now carried on almost exclusively in the gullies between the off-shore banks and on the outer edges of the banks in water one hundred to three hundred and fifty fathoms in depth.

Captain Benjamin Ashby, of Noank, Connecticut, who is familiar with the fisheries south of Cape Cod, informs me that they frequent the deepest water in the spring and fall, and that they come up in the shoal water, in sixty or seventy fathoms, in May and June, while in July they begin to go out again into deep water, and by the latter part of the month are on the way into the gully on northeast part of George's Bank.

Captain Collins briefly expresses his views as follows: "Halibut are found in the deep water—say from one hundred to two hundred and fifty fathoms in depth—on the edge of all the banks from George's to the Grand Bank the year round. Sometimes, however, they are found more numerous in comparatively shallow water in the winter and early spring. This was the case in the winters and springs of 1875–'76 and 1876–'77, as well as in the year preceding. But in 1878 there was no great

catch of Halibut in less than one hundred fathoms on any of the banks. The great schools that were found in the western part of the Grand Bank in February and March, 1876 and 1877, appear to be migrating. The fish that were found to the south of latitude 44° north were mostly small-sized white Halibut. They went off the bank into deep water, and nobody knew what became of them. Those that were caught to the north of this parallel were mostly large gray fish, and were traced as far as Saint Peter's Bank. These are possibly the same fish—they are certainly the same kind of fish—that struck in on the western coast of Newfoundland in the summer months in pursuit of capelin."

Capt. George A. Johnson states that the large Halibut frequent the outer and deeper part of the banks, while the little "bull fish" lie inside, on shallower ground, and are caught on the inner end of the trawl lines, but that sometimes the large Halibut come up on the shallow grounds.

On the coast of Newfoundland, Anticosti, and Labrador, Halibut frequently run inshore in summer after capelin. When in shallow water near the shore they are usually wild and very active. The fishermen within eight years have extended their fishing much farther out to sea; previous to that time the greater part of the Halibut were taken on the top of the Grand Bank in thirty to fifty fathoms of water, but after the beginning of April the fish went elsewhere, and the fishermen lost sight of them. They soon learned, however, to follow them down the slopes of the banks, but before 1876 had rarely fished in water deeper than seventy to ninety fathoms. Since that time, as has already been stated, fishing has been carried into twice or three times that depth. All that can at present be said in explanation of their movements is that they occur in great schools, and, soon consuming the available food in any one locality, are obliged to shift their position to some other place where they can find fresh pastures. It does not seem possible that their migrations can be caused by conditions of temperature or are in connection with their breeding habits. During the breeding season the schools sometimes remain for months in one locality, and these places are generally of limited extent. While spawning but little if any food is found in their stomachs.

Food.—They are large-mouthed, sharp-toothed, voracious, although adapted for life upon the bottom, and doubtless feed largely upon crabs and mollusks; they are particularly fond of fish of all kinds; these they waylay, lying upon the bottom, invisible by reason of their flat bodies, colored to correspond with the general color of the sand or mud upon which they rest. When in pursuit of their prey they are active, and often come quite to the surface, especially when in the summer they follow the capelin to the shoal water near the land. They feed upon skates, cod, haddock, menhaden, mackerel, herring, lobsters, flounders, sculpins, grenadiers, turbot, Norway haddock, bank clams, and anything else that is eatable and can be found in the same waters. Captain Ashby tells me that common flounders and flat fish are among their most favorite food; they follow them up on the shoals of George's and Nantucket; they lie in wait for them on the sand-rips and catch them as they swim over. He has seen a half bushel of flat fish in the stomach of one; they stow them away very tightly. He has often seen Halibut chasing flat fish over the surface of the water. About Cape Sable their favorite food seems to be haddock and cusk. He has seen eight or ten pounds of haddock and cod taken out of one of them. When they are on the shoals they are sometimes filled with flat-fish, haddock, cusk, sculpin, and herring, but when in deep water he has found very little food in them. They eat crabs and other crustaceans, but shells are rarely found in their stomachs, except those of clams and mussels.

Captain Hurlbert tells me that when the vessels are dressing codfish on the Grand Banks, and the back-bones and head are thrown overboard, these are frequently found in the stomachs of Halibut taken in the same locality.

Mr. William H. Wonson, of Gloucester, has seen live lobsters six inches long taken from the stomach of a Halibut. Captain Marsh states that they feed on whiting, mackerel, and herring. He remarks: "Halibut will drive off any kind of fish and take charge of the ground."

At the meeting of the Boston Society of Natural History, in 1852, Dr. W. O. Ayres stated that he had seen a block of wood, a cubic foot in dimensions, taken from the stomach of a Halibut, where it had apparently lain for a long time. Capt. George A. Johnson found an accordion key in one of them. Olafson, in 1831, studying them on the coast of Greenland, found not only pieces of iron and wood in them, but in the stomach of one individual a large piece of floe ice. Captain Collins has observed that they often kill their prey by blows of the tail, a fact which is quite novel and interesting. He described to me an instance which occurred on a voyage home from Sable Island in 1877: "The man at the wheel sang out that he saw a Halibut flapping its tail about a quarter of a mile off our starboard quarter. I looked through the spy-glass, and his statement was soon verified by the second appearance of the tail. We hove out a dory, and two men went in her, taking with them a pair of gaff-hooks. They soon returned bringing not only the Halibut, which was a fine one, of about seventy pounds' weight, but a small codfish which it had been trying to kill by striking it with its tail. The codfish was quite exhausted by the repeated blows, and did not attempt to escape after his enemy had been captured. The Halibut was so completely engaged in the pursuit of the codfish that it paid no attention to the dory, and was easily captured."

The Halibut, in its turn, is the prey of seals, of the white whale, and of the various large sharks, especially the ground shark, or sleeping shark, in the stomachs of which they have sometimes been found; their sides, I am told by Captain Collins, are often deeply scarred, probably by the teeth of the sharks, or in their early lives by mouths of larger individuals of their own kind.

SPAWNING.—There is diversity of opinion regarding their spawning. Some fishermen say that they spawn at Christmas time, in the month of January, when they are on the shoals. Others declare that it is in summer, at the end of June. Capt. George A. Johnson, of the schooner "Augusta H. Johnson," of Gloucester, assures me that Halibut "spawn, just like the human race, at any time of the year." In April, 1878, he was fishing on Quereau Bank, and found large and small Halibut, the large ones full of spawn. In May he was on the Le Have Bank, where he found only small male fish full of milt; in June he was on Le Have again, fishing in shallow water, where he found plenty of "small bull fish, with their pockets full of milt"; in July he was again on Quereau Bank, where he found a school of small and big male and female fish, all, apparently, spawning, or ready to spawn, "with milt and pees soft"; in August he was on the outer part of Sable Island, where he found females full of spawn.

Captain Ashby, speaking of the Halibut on George's Banks, states that roe is always found in them in May and June. The roes of a large Halibut caught by him in 1848 on the southwest part of George's, and which weighed 356 pounds, after it had been dressed and its head removed, weighed 44 pounds. He states that the Halibut in this region have spawn in them as long as Connecticut vessels continue to catch them, or until September. He has seen eggs in Halibut of twenty pounds' weight, and thinks that they begin to breed at that size. The spawn of the Halibut is a favorite food of the fishermen of Southern New England, though never eaten by those of Cape Ann.

Captain Hurlbert, of Gloucester, tells me that on the Grand Banks of Newfoundland the halibut school used to come up in shoal water, in forty or fifty fathoms, in summer, and that the spawn was ripest about a fortnight later. In August, 1878, he found many with the spawn already run out. At that time several Gloucester fishermen reported that the Halibut on Le Have and Quereau Banks were full of spawn. Captain Collins told me that in July and August, and up

to the first of September, they are found here with the ovaries very large, and are often seen with the ova and milt exuding. The ovaries of a large fish are too heavy to be lifted by a man, without considerable exertion, being often two feet or more in length. At this time very little food is found in their stomachs. In September, 1878, the Fish Commission obtained from Captain Collins the roes of a fish weighing from 190 to 200 pounds, taken by the schooner "Marion" on the 13th of the month on Quereau Bank. This fish was taken at the depth of 200 fathoms, and the temperature of the water was roughly recorded at 36° F. These ovaries were put into a basket with ice and brought to the laboratory of the Fish Commission, where they were found to weigh seventeen pounds, two ounces. Part of the eggs were nearly ripe, and separated readily, while others were immature and closely adherent to each other. A portion of the roe, representing a fair average of the size of the eggs, was weighed, and was found to contain 2,185 eggs; the weight of this portion was two drams. The total number of eggs was from this estimated to be 2,182,773. It is not yet known whether the eggs float or rest upon the bottom, nor is it known how long is the period of incubation, nor what is the rate of growth of the fish. As has already been mentioned, young fish are very unusual; the smallest ever seen by Captain Ashby in Southern New England was taken on Nantucket Shoals, and weighed two and a half pounds after it had been eviscerated.

ABNORMAL INDIVIDUALS.—Left-handed Halibut are sometimes taken. Perhaps one out of five thousand is thus abnormal in its form, having the eyes upon the left rather than upon the right hand side of the head.

Halibut with dark spots or patches on the under side of the same dark color as the back are occasionally taken. These are called by the fishermen "Circus Halibut." They are generally of medium size, and thick, well-fed fish.

61. THE SAND DAB, OR ROUGH DAB.

The Sand Dab, or Rough Dab, *Hippoglossoides platessoides*, also sometimes known as the Rusty Flounder, is taken in winter by the line fishermen of New England, and small quantities are doubtless brought to market and sold with other flat fishes without discrimination as to species. It often attains the length of twenty to twenty-four inches, and the weight of two to five pounds, and is, in all respects, a desirable food-fish, being highly esteemed on the other side of the Atlantic. In summer, individuals of this species are to be found only in very deep water, thirty fathoms or more, on the New England coast, and, though never very abundant in any one locality, might be taken in considerable quantities, in company with the Pole Flounder, by the use of a trawl-net, or even by specially devised trawl-lines.

The Rough Dab has not been observed south of Wood's Holl, Massachusetts, but ranges north to Greenland, is abundant on the English coast, and is a well-known food-fish of Scandinavia. Its breeding habits in our waters have not been observed, but in Southern Sweden the spawning time is in April and May. It is a large-mouthed species, feeding upon fish as well as upon large invertebrates, such as crustaceans and annelids, and mention has been made of it more on account of its possible value in the future than for its present importance.

62. THE GREENLAND TURBOT.

The Greenland Turbot, *Platysomatichthys hippoglossoides*, though never occurring in our inshore waters, is found on the off-shore banks, as far south as George's Bank, and a certain quantity of them is usually brought to New York every winter. It is emphatically an arctic species, being abundant on the coast of Greenland, often found at Holsteinborg and beyond, and along this entire coast very eagerly sought by the natives. The Eskimo name is "Kalleraglik," and the fish is also known as "Little Halibut." In Günther's great work on "The Fishes of the British

Museum," he has confused this species with the true Halibut, making it appear that only the former is to be found on the coast of North America. In Northern Greenland the Turbot is found only at very great depths, and is fished for, in water of three hundred and fifty to three hundred and eighty fathoms, through holes in the ice, over certain banks in Omenak Fiord and at the mouth of the Jacob's-Haven ice-fiord, which is also packed with great ice-floes. It is said to be found only in the ice-fiords and between the great ice-fields, and there only in the coldest months of the year.

In South Greenland they are taken on the oceanic banks at a depth of sixty to one hundred and eighty fathoms, though there considered to be not so abundant as in North Greenland. In Fortune Bay, Newfoundland, according to Captains G. Johnson and A. Leighton, of Gloucester, they are very abundant in sixty to three hundred fathoms, and are caught chiefly in winter. They are also obtained by the Gloucester halibut fleet on the outer edge of the oceanic banks, in two hundred and fifty to three hundred fathoms of water.

Their habits are not at all well understood, but it would appear from the statements of several experienced fishermen, whom I have questioned, that they occur on the very edge of the continental slope in deeper water than the true Halibut, in fact in places where the slope is so nearly perpendicular that the Halibut can hardly hold their places on the bottom. This species is more symmetrical than any other of the family on our coast, and, moreover, is colored upon both sides of the body—a fact which indicates that its movements are more like those of the ordinary symmetrical fishes and that it can rest with the body in a vertical attitude.

It would seem probable that its chosen haunts are along the declivities of the outer slope of the continental plateau, where abundance of food is known to occur, and where other fishes are not so well adapted to live. Many hundreds of pounds are caught, every year, on the halibut trawls, and the fish are frequently iced and brought to market with the Halibut, and frequently eaten by the fishermen themselves. The greater portion of those brought to New York in winter are, however, taken on trawl lines at the mouth of Fortune Bay, and brought down by the vessels which go there to procure cargoes of frozen herring. It is impossible to obtain statistics of the quantities thus brought in, because the market returns do not discriminate between the different species of flounders and flat fishes.

The Greenland Turbot is an exceedingly palatable fish, its flesh being firm, white, and less dry and more delicate in flavor than that of the Halibut. The average weight is from ten to twenty-five pounds. In Greenland they are perhaps more highly esteemed than any other fish. The Greenlanders begin fishing as soon as the fiords are frozen over and the white whales, which prey greedily upon this fish, have left the entrances open. They fish through holes in the ice, and attach little threads at intervals to their lines, so that they may better see the motion which the nibbling fish makes. Under favorable circumstances a man may take ten to eighteen of these fishes daily. The fishery continues from January to the middle of March, sometimes, however, only a week or two, and usually only about a month. The fish are cut into strips and dried for the consumption of the Danish colonists. It is said that a very fine oil can be made out of their fat, so that in hard times the fish serves to warm and light their houses as well as feed their occupants. In South Greenland they are not so numerous, but are constantly sought for, being taken in company with the sea perch, or red fish.[1]

83. THE POLE FLOUNDER, OR CRAIG FLOUNDER.

This fish, *Glyptocephalus cynoglossus*, often known as the Deep-sea Flounder, was first observed on this coast in 1877, when numerous specimens were obtained by the United States

[1] These facts are taken from Rink's "Greenland."

Fish Commission, in the deepest part of Massachusetts Bay. Specimens have since been obtained south of Cape Cod, at a depth of one hundred fathoms or more, by the Fish Commission, and by Professor Agassiz, off the entrance to Delaware Bay, at a depth of three hundred and ninety-five fathoms. The Pole Flounder appears to be a permanent resident, throughout the whole year, in the deep basins of Massachusetts Bay and on the edge of the continental slope, and is found abundant in Bedford Basin, the inner expansion of Halifax Harbor, at a depth of thirty-seven fathoms. It ranges nearly to Greenland, and is also found on the coast of Northern Europe, where it is found in the Trondhjem Fjord, in latitude 65°, and south to the coast of Ireland. Its thermal range appears to be confined by the limits 34° and 45°.

It breeds abundantly in our waters in summer time, numerous individuals, full of spawn, and young from half an inch upward, having been taken, from July to October, in various localities.

The Pole Flounder has been pronounced, by all who have tasted it, a most delicious food-fish, resembling more closely than any other species on our coast the English Sole, having a great quantity of peculiarly flavored mucilaginous tissue about the base of the fins; it has never been taken by our fishermen, because, on account of its exceedingly small and weak mouth, it could not hold fast to an ordinary hook and line; and, should it ever come into demand, it will be necessary for our fishermen to introduce the English trawl-net.

64. THE SPOTTED SAND FLOUNDER.

The Turbot, or Steinbutt, *Rhombus maximus*, and the Brill, or Glattbutt, do not occur in our waters, although many attempts have been made to prove that they do. The nearest representative of the Turbot is the Spotted Sand Flounder, *Lophopsetta maculata*, a species found from Bucksport, Maine,[1] to Fort Macon, North Carolina, variously known along the coast as Water Flounder, Window-pane, and Daylight; the latter name refers to the remarkable thinness of the fish, its flesh being so transparent that, when held to the light, the shadow of an object on the other side can be seen. Its flavor is good, but the amount of flesh is so small that it is of no consequence as a food-fish. There are other smaller representatives of the family on the southern coast, and in deep water from Cape Cod southward, belonging to the genus *Citharichthys*, which, although edible, are never eaten.

[1]According to Mr. G. A. Boardman, of Calais, Maine, an individual was taken in Passamaquoddy Bay in September, 1880.

J.—THE COD FAMILY AND ITS KINDRED.

The Codfish and its allies constitute, from an economical point of view, the most important of all the families of fishes, containing, as it does, a large number of species, most of them of considerable size, distributed throughout all parts of the northern hemisphere, usually found together in great numbers, readily captured, and easily preserved for future use.

An elaborate discussion of the geographical distribution of the cod family, and its relations to fisheries and commerce, by Karl Dambeck, was published in "Gæa," in 1877. A translation of this paper may be found in the Report of the United States Commission of Fish and Fisheries, Part V, 1877, pp. 531–557. This paper is not without value, although it contains many false statements, the writer appearing to have been but slightly acquainted with the more recent ichthyological discoveries. In the translation referred to, the paper has been revised and annotated by Dr. Bean, and is sufficiently accurate so far as the American species are concerned.

65. THE COD—GADUS MORRHUA.

NAMES OF THE CODFISH.—Mr. J. Carson Brevoort, of New York, contributes the following interesting sketch of the names applied to the cod family by the different nations of Europe:

"The appellations under which the weather-dried Codfish, split and stretched on a short stick, is known throughout the civilized world can all be traced to one common root, based upon the mode of preparation for the market.

"Among the Greeks the large Codfish were called *Bacchi*, from Bacchus, a rod. By the Latins the fish was named *Gadus*, from a Sanscrit root *cad* or *gad*, a rod. We find this root in English in 'goad,' and, perhaps, in 'cat-o'-nine-tails'; in Gaelic *gad* and *godan*, signifying a small rod. By the Iberians the dried Cod were called *Bacalaos*, from Baculeum, a small stick.[1] This points also to the root of the French *Baguette*, a rod, *Bilboquet*, the toy known as cup and ball, really a *stick* and ball, and other words. By the Anglo-Saxons it was called the *Cod*, from the word *gad* or *goad*, a rod. By the Germans it was known as the *Stockfisch*, from *Stock*, a stick.

"The Hollanders varied a little from this, and as far back as the year 1400 called it the *Kabeljaauw*, which seems to be from the Dutch *gabel*, a fork. They also called it the *Bakkeljauw*.

"The French *Morue* is not from the above root. It may be from the Celtic *Mor*, the sea. The French, however, never prepared the Cod by drying it on a stick, but salted it as the *Morue verte*, or green Cod. The French *Molue* is merely a change in the liquid consonants.

"When the Cod is dried on the downs it is called Dunfish, from the Gaelic root *Duin*, a hill. If dried on the rocks it becomes the *Rock Cod*, or the *Klippfisk* of the Norwegians. Among these last the Cod is called the *Dorsct*, or *Torsk*, in English *Tusk*, from the Gothic *Dürren*, to dry.

"The English 'Aberdeen fish,' or French *Laberdan*, is from the Gaelic *Abar*, the mouth; *Dan*, a river, or fish caught near the river's mouth."

These remarks are suggestive in the extreme, since they explain the origin of almost all of the names now applied to this species both in its fresh and cured condition.[2]

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[1] The rod held by Mercury was called a *Baculeum*.

[2] Skeat in his Etymological Dictionary, recently published, does not confirm the views advanced by Mr. Brevoort, remarking, "I suppose that this word *cod* must be the same as the Middle English *codde* or *cod*, a husk, bag, bolster; though the resemblance of the fish to a bolster is but fanciful. It is obvious that Shakespeare knew nothing of the Linnæan name *gadus* (Greek γαδος), nor is the derivation of *cod* from *gadus* at all satisfactory."

The name by which this species was known among the Narragansett Indians is indicated by the following sentence from Roger Williams' "Key into the Languages of America":

"Panganaut, tamwock. Cod, Which is the first that comes a little before the Spring."

In the vicinity of Cape Ann the young Cod, too small to swallow a bait, are sometimes known to the fishermen as "Pickers," and throughout all Eastern Massachusetts the name "Scrod," or "Scrode," is in common use. In its primary meaning it seems to refer to these small fish slightly corned, in which condition they are a favorite article of food, but the name is also transferred to the young fish themselves. The fishermen recognize several varieties of Cod for which they have different names. Rock Cod are those which are found in shoal water among the reefs and ledges, and which usually are of a dark color: these fish are often brilliant red in color, owing to the fact that the small animals upon which they live feed upon the red algæ, abundant in those localities, and from them have absorbed the red coloring matter into their tissues. "Rockling" are probably young Rock Cod. In the vicinity of Scituate, Massachusetts, Rock Cod are also called "Native Cod."

Another class of names appears to apply to those fish which live near the shores, but which are less closely limited to the reefs. These are called "Shoal-water Cod," "Shore Cod," "Inshore Cod," "Worm Cod," "Clam Cod," "Black Snappers," "Black Biters," "Brown Cod," "Ground Keepers," and "Ground Tenders" or "Groupers."

Still another class of fish is known by such names as "Deep-water Cod," "Bank Cod," and "School Cod."

There are also certain local schools of fish which have names of their own; for instance, the "Herring Fish" or "Herring Cod" of Southeastern Maine, and the "Squid School" of Nantucket and other parts of the coast, the "Pasture School" of Cape Ann, and the so-called "Shad School" which frequented Massachusetts Bay between 1815 and 1830.

In Southeastern Maine the name "Pine-tree Cod" is also in use. It is difficult at present to determine exactly to what extent these names are used and what their precise meaning may be, but it is almost certain that each community of fishermen has its own peculiar names by which to designate local peculiarities of habit and movement.

In the markets the Cod from George's Bank are usually classed as "George's fish," and are considered to be of superior value. George's fish are very fat fish with white "napes." This name is becoming a commercial term to describe Codfish of the finest quality. No one of these names, excepting Rock Cod, or Red Cod, appears to be in use in Great Britain, although there, as here, there are various names of local significance, which are of little interest, however, to Americans.

"Bank Cod" and "Shore Cod" are commercial names, used in the same manner as the name "George's Cod."

HISTORY OF THE CODFISH IN AMERICA.—As early as 1415 A. D., English vessels frequented the fishing grounds near Iceland, and it is claimed by some authorities that the Banks of Newfoundland were known to the Basques centuries before the discovery of the American continent. The Banks of Newfoundland were among the principal inducements which led the English to establish colonies in this country, and in the records of early voyages are many allusions to the abundance of Cod along our shores.

In the Appendix may be found an essay, by Mr. Robert S. Rantoul, on "The Cod in Massachusetts' History," a paper read at a field meeting of the Essex Institute at Gloucester, September 14, 1866. It is really an epitome of the early history of the cod fisheries of the United States, containing much interesting information upon the use of the Codfish upon the seal of Massachusetts and upon the colonial coinage.

A Nova Scotia coin or bank-token has upon it the figure of a Codfish. Upon the obverse is a plow with the legend "Speed the Plough," upon the reverse a salted Codfish with the words, "Success to the Fisheries."

DISTRIBUTION OF THE COD.—The Codfish is found in the North Atlantic, in the North Pacific, and in the Polar Ocean, its range extending far beyond the Arctic Circle. It seems unnecessary to enumerate all the localities in which it has been observed, for its geographical range may be defined with sufficient accuracy and by a much more comprehensive statement: In the Western Atlantic the species occurs in the winter in considerable abundance as far south as the mouth of the Chesapeake Bay, latitude 37°, and stragglers have been observed about Ocracoke Inlet.[1] The southern limit of this species may safely be considered to be Cape Hatteras, in latitude 35° 10′. Along the coast of the Middle States, New England, and British North America, and upon all the off-shore banks of this region, Cod are found usually in great abundance, during part of the year at least. They have been observed also in the Gulf of Boothia, latitude 70° to 75°, and in the southeastern part of Baffin's Land to the northward of Cumberland Sound, and it is more than probable that they occur in the waters of the Arctic Sea to the north of the American continent, or away round to Bering Straits.[2]

The Cod has been observed on the western coast of Greenland. In the North Atlantic the range of the species extends to Iceland and Spitzbergen, latitude 80°; along the arctic coast of Europe, as far as Eastern Finmark, and probably round to Siberia; while southward it ranges at least to Brittany. Its southern limit is probably near the Bay of Biscay, latitude 40°, although Yarrell states that it is found south to Gibraltar. It does not enter the Mediterranean, but penetrates into the Baltic to the coast of Western Russia. Its distribution in the North Pacific is not so well understood, though it appears to occur in the same abundance on all the off-shore banks of this region, and also close to the coasts to the north of the Straits of Fuca. According to Jordan, there is said to be a cod bank outside of the mouth of the Columbia, but the species at present is of no economic importance south of Alaska. A full discussion of the Alaskan Codfish is given below by Dr. Bean in the chapter on THE ALASKA COD-FISHERY.

The Cod enters fresh water upon occasion.[3] It is found, according to Canadian authors, well up the estuary of the Saint Lawrence, though how far up is not definitely stated, probably not beyond the limits of brackish water. Dr. C. C. Abbott records that on the 23d or 24th of January, 1876, a healthy, strong, active Codfish, weighing nearly four pounds, was taken in a draw-net in the Delaware River near Trenton, New Jersey; the stomach of the fish showed that it had been in river-water several days. Many of them had been taken about Philadelphia between 1856 and 1869.[4]

Mr. George R. Smith, of Millbridge, Maine, states that Cod are found all along the coast, even entering brackish water at the mouths of rivers.

Mr. Wilson M. Albee, of Mohegan, Maine, affirms that Cod occur in all places along the coast of that region, even in brackish water.

Mr. A. T. Gamage, of Damariscotta, Maine, says: "There is not a place of any extent on the coast of Maine and seaward where Cod are not found. They occur from the edge of the breakers

[1] The mackerel schooner "Relenter," of Gloucester, April 5, 1880, caught, on one hand-line, some 600 pounds of large Cod, with mackerel bait, in twenty fathoms of water, when about eight miles off Cape Charles.—A. H. CLARK.

[2] RICHARDSON: Fauna Boreali Americana, p. 243.

[3] "Forest and Stream," December 25, 1873, contains the following astounding statement, which, of course, is entirely unworthy of credence: "Three Codfish, weighing six pounds each, were caught in the Saint John's River, Florida, near Palatka, last week; the first of the kind ever caught in Southern waters. The 'Herald,' says Captain Vogel, of the steamer 'Dictator,' pronounced them genuine Codfish."

[4] American Naturalist, iv, p. 116.

out to seventy-five fathoms and up to fifty miles and further, wherever any bank has been discovered. Quite frequently they enter brackish water in pursuit of their natural food."

Thomas Day, of Parker's Island, Maine, says that small Cod have been caught in the Kennebec River.

Mr. M. A. Hanna, of Bowery Beach, says that they are sometimes caught in rivers at some distance from the sea, where the water at the surface is quite fresh.

These statements are confirmed by several other persons. The New York "Evening Post" of February 6, 1877, says that a six-pound Codfish was taken on February 1 in the Hudson River above Peekskill, New York.

THE SCHOOLING OF THE CODFISH.—Before taking into consideration the periodical movements of the Codfish, it seems necessary to study the manner in which they assemble together in schools. Mr. Earll, who has studied with great thoroughness the habits of the Codfish about Cape Ann, writes as follows upon this topic:

"In examining the Codfish landed from time to time, one cannot but notice the great individual variation in the species. But in addition to 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 one hundred and fifty to three hundred 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 four hundred 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 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 twelve and fourteen 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 eight to nine hundred 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 Codfish 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 sixty to seventy 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 twenty to twenty-five thousand 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 being of uniformly large size with a few very large. Of over five thousand, 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 dogfish (*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 visits 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 has just left the shore, and that they remain on these grounds for a few days or weeks on their way to deeper water."

I have before me the statements of ninety-four fishermen, most of whom are of the opinion that the Cod associate together in schools throughout the entire year; many of them, however, speak of particular schools of very large size which they noticed at particular seasons. Captain Atwood, on the other hand, makes the assertion that the Cod never school, but that they wander independently over the bottom in search of food.

It seems most reasonable to suppose that the Codfish, like most other species which habitually feed on the bottom, are less disposed to wander together in great bodies from place to place than the surface-swimming fishes which usually feed upon substances or animals which are found collected together in one place in great quantity. The Codfish, being habitually bottom-feeders, find their food, it is probable, with more or less uniformity, over the areas which they frequent, and are ordinarily met with moving about independently. They are most likely to occur in great numbers in places where food is particularly abundant. At certain seasons of the year they are brought together by a common desire for wandering together from place to place in immense bodies, sometimes their object being a united attack upon some special kind of food only to be found at that season, and in particular places. The capelin and lant schools, known to the fishermen of Newfoundland, Labrador, and the Grand Banks, are examples of such association, as also is the herring school observed in the spring in Massachusetts Bay, and the great schools known on the coast of Norway under the name of *Lödde-fisk*.

Capt. Epes W. Merchant, of Gloucester, tells me about a remarkable school of Codfish which frequented Massachusetts Bay between the years 1815 and 1830. This was called the "shad school." They continued in the bay from early April until the middle of May. They were caught with alewives and shad for bait. The fishermen were accustomed to get these fish for bait as soon as they began to run. The Cod seemed to be waiting for them. The "shad school" was composed of young, sharp-nosed, bright-eyed school fish of regular size, very different from the ground-tenders or grubbers.

Professor Baird has made some interesting generalizations concerning the effect upon the abundance of Cod of the decrease in the shad and alewives off the mouths of our rivers caused by over-fishing in inland waters.[1]

Another cause of the assembling of the Codfish together is the reproductive instinct, in obedience to which the fish gather together in localities where the temperature and depth of water are suitable for the deposition of eggs. A school of this kind is the so-called "pasture school," already referred to in the quotation from Mr. Earll, and the great schools—the so-called "fish-mountains"—which make their appearance on the coast of Norway in January, February, and March, and which have been so well described by Professor Sars.[2]

The fisheries carried on at this time are called "spawn fisheries" to distinguish them from those which are carried on later in the spring on the coast of Finmark, the object of which is the capture of Codfish following schools of bait.

"Codfish," continues Mr. Earll, "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

[1] Report United States Commission of Fish and Fisheries, pt. ii, 1874, pp. xi–xiv.

[2] Report of the "Practical and Scientific Investigations of the Cod Fisheries near the Lofoden Islands," made during the years 1864–'69 by S. O. Sars; translated by H. Jacobson. Report United States Commission of Fish and Fisheries, pt. v, 1879, pp. 565–661.

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 forty 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 off-shore 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.

"Codfish 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."

MIGRATIONS AND MOVEMENTS OF THE SCHOOLS.—The causes which influence Codfish to assemble together in schools also influence their movements from place to place. It seems most probable that while great numbers of these fish may remain together in the same locality, feeding upon the same kind of food without it being said that they are schooling, a movement from place to place is, however, usual, in obedience to some tangible law, and is made simultaneously by numerous individuals.

The migrations of the Codfish are usually of the class which I have described under the name "bathic."[1]

The Cod, like most of the other species which migrate to and from the shore instead of northward and southward, is, doubtless, more or less dependent upon temperature conditions than fishes like the menhaden and the blue-fish, and, as Mr. Earll has suggested,[2] the abundance of food doubtless has much more influence upon its movements. We cannot doubt, however, that the Cod moves periodically to and from the shore as a direct result of the seasonal changes of temperature. The Cod prefers a temperature of from 35° to 42° F., approximately, and this it secures in a temperate climate, such as that of Southern New England, by remaining on the off-shore banks in

[1] Report of United States Commissioner of Fish and Fisheries, pt. v, 1879, p. 51.
[2] *Op. cit.*, p. 707.

fifteen to thirty fathoms of water, coming into the shallows in winter. On the coasts of Labrador, Newfoundland, Nova Scotia, and Eastern Maine, moving to and from the shore from deeper to shallower water and *vice versa* to secure at different seasons of the year a temperature environment best suited to their needs, they are near the shore in summer and in deep water in winter.

In Norway they are caught, to some extent, in the fiords in the summer season, though more are caught in winter, while in summer great numbers of them still remain on the off-shore banks.

Professor Hind gives this exposition of the movements of the Cod on the Labrador coast.[1]

"The following tables show the periods of the first arrival and last catch of Cod on the Newfoundland and Labrador coasts. In framing these tables I have been careful to eliminate extreme seasons, for the Cod have been known to approach the shore during an exceptionally early season, a fortnight or three weeks sooner than during the average of years. Early and late springs occur in the movements of fish just as irregularly as in the movements of migratory birds or in the leafing and flowering of plants. The salmon and the Cod generally come within a week of one another, and the Eskimo of Ukkasiksalik have a tradition that the salmon may always be looked for on the day of the first spring tide after the 16th July. In 1875, a very late season, Codfish were not taken before the 7th August; this year they came in on the 20th July, and this accords with the experience on other parts of the coast.

"*Table showing the approximate mean date of arrival of Cod, mean date of departure, and mean length of the fishing season for Cod, in Northeastern Newfoundland, Southern and Northern Labrador.*

Lat.	Locality.	Mean date of arrival.	Mean date of close of fisheries.	Mean length of fishing season.
	NEWFOUNDLAND.			
° ′				
47 30	Conception Bay	June 1	Nov. 20	
48 20	Bonaviata Bay	June 10	Nov. 10	
48 30	Notre Dame Bay	June 20	Nov. 10	
50 00	Cape Saint John to Par. Point	June 20	Nov. 1	143 days.
49 30	White Bay	June 10	Nov. 1	
51 00	Cape Rouge Harbor	June 10	Nov. 1	
51 30	Cape Bauld to Cape Onion	June 20	Oct. 20	
	(Over four degrees of latitude.)			
	SOUTHERN LABRADOR.			
52 00	Chateau Bay	June 20	Oct. 1	
53 24	Batteaux	July 12	Oct. 10	87 days.
54 26	Indian Harbor	July 15	Oct. 1	
54 56	Cape Harrison	July 18	Oct. 1	
	(Over three degrees of latitude.)			
	NORTHERN LABRADOR.			
55 14	Aillik	July 20	Oct. 1	
54 57	Kypokok	July 20	Oct. 1	
55 27	Hopedale	July 20	Oct. 1	
53 30	Double Island Harbor	July 22	Oct. 1	
55 52	Ukkasiksalik	July 28	Oct. 1	61 days.
56 33	Nain	July 28	Oct. 1	
57 30	Okak	July 28	Oct. 1	
58 30	Hebron	Aug. 15	Sept. 25	
58 46	Lampson	Aug. 15	Sept. 15	
	(Over three and a half degrees of latitude.)			

"From this table, imperfect as it is, we may deduce the following law: 'Over an area extending northerly from Conception Bay for seven hundred miles, the Cod approach the shore about one week later for every degree of latitude we advance to the north.'

[1] HIND, H. Y.: The Effect of the Fishery Clauses of the Treaty of Washington upon the Fishermen of British North America. Halifax, 1877.

"The table shows also that for a period of about forty days the cod fishery goes on simultaneously during August and September, throughout the length of a coast line extending from latitude 47° to latitude 50° 30′, or more than seven hundred statute miles in one continuous line. Hence it appears that the migrations of the schools of this fish are merely from deep-water winter feeding grounds to the nearest coast spawning grounds, and from the coast to the nearest deep-water feeding grounds again. The coast migrations during the summer months appear to be of equally limited extent, and schools of Cod frequenting any particular coast may be said to be *indigenous* to it.

"On the Labrador, especially in well-known deep bays, such as Hamilton Inlet, the coast movements of the fish appear to be very regular, and determined to a large degree by the tidal currents. The caplin generally precede the Cod by a few days, and these fish are known to approach the coast and enter sandy coves for the purpose of spawning. The same meteorological influence which guides the movements of the Cod affects also the periods of spawning of the caplin. I saw numerous schools of this fish spawning in Trinity Bay on the 27th June; a month later they spawn in Kypokok Bay, and still later further to the north."[1]

I have before me the statements of nearly a hundred observers which I hope to discuss more fully at some future time. These opinions confirm, in a very striking manner, the generalization just stated. They show that while on the coast of Maine the Cod leave the immediate shores in the autumn, not reappearing in any considerable numbers until late in the following spring, south of Cape Cod they approach the shore only in the winter season, while during the summer they keep out in the cold Labrador current, which extends south to the inside of the current of the Gulf Stream. In Vineyard Sound, Buzzard's Bay, and off the shores of Connecticut, New York, Delaware, New Jersey, and even in Eastern Virginia, there is excellent cod fishing during the winter season. "A wise provision of nature," remarks Professor Baird, "in the absence of so many species that supply food during the summer."

It will probably be found that fishing in deeper water in these same regions in summer will bring to light an abundance of Cod.

"In European seas," writes Professor Hind, "the depth at which the fishermen look for Cod varies with the season of the year, and is a point toward which much attention is paid in Norway and England. On the Dogger Bank, the smacks fish at the following depths during the months named:

	Fathoms.
December	12 to 15
January	14 to 18
February	18 to 22
March	10 to 12"

From Professor Hind's pen the following paragraphs are also taken:

"When the coasts of Finmark are thronged with fishermen catching their fares of the 'Lodde,' or Summer Cod, the shores of Northeast Newfoundland and the shore of the Gulf of Saint Lawrence are alive with fishermen successfully capturing the same variety of fish in British American waters; and when the Russian on the Murmanian coast is laying in his winter stock of Cod, and accumulating a large overplus for a foreign market, the Newfoundlander and the Labradorian are securing their fares as far as the Moravian Missionary Stations, Okak and Nain. So, also, in the North Sea and on the coast of the British Isles, around the Faroe Islands, all along the Icelandic shores, on the south coast of Greenland, off Arksut Fiord, away up north to Torske Banks, and down the Atlantic

[1] HIND: *op. cit.*, pt. ii, p. 70.

coast of America to over the Grand Banks, and as far as, and even beyond, Saint George's Shoal, the Cod is taken simultaneously and in great abundance.

"Local variations of days, and even weeks, occur in a coast line or stretch of shallow sea of not more than one hundred miles in length; but these arise from the one great leading cause which guides the Cod in its approach to known feeding grounds on the coast or known banks at sea. This leading cause is temperature, which determines the movement toward the coast of the various forms of marine life on which the Cod, inhabiting different waters, is accustomed to feed. . . . The Cod, caught on each stretch of coast line within variable but tolerably well-defined limits, are *indigenous* to the sea area adjacent to the sea-coast which they frequent.

"Thus the winter haunts of the Codfish on the Northern Labrador coast are the slopes of the *great range of outside banks on that coast. The summer haunts of the 'Winter Cod' caught on* the coast of Norway during the winter season, are on the slope of the 'Storegg' and its continuations which lie seawards from the Norwegian coast, following the edge of the barrier separating the 'polar deeps' from the shallower coastal seas. The seasonal movements of the Cod are reversed in this case, purposely introduced, but have afforded a beautiful illustration of the principles adopted and confirmed by Professor Baird and of the influence of marine climate on fish-life."[1]

The depth at which Codfish are found varies greatly with the season and locality. It is stated by Mr. Earll that they seem to prefer water less than seventy fathoms deep, and that by far the greater numbers are caught in from eighteen to forty fathoms. This generalization will doubtless hold true for the whole coast of North America. Many of our correspondents state that they are occasionally seen in water two or three feet in depth. In the course of the recent explorations by Professor Agassiz, Cod were found three hundred fathoms below the surface.

"In February, 1879, there was good fishing in three fathoms of water, within a few rods of shore in Ipswich Bay, while in May of the same year large numbers were taken in one hundred *and ten fathoms from the channel near Clarke's Bank.*"

It would be extremely interesting to know the extent of the migrations of Codfish, from deep to shallow water and back again, on different parts of the coast. This, however, varies with local conditions. There have already been many observations made, the study of which will doubtless aid in the solution of this problem, but it is exceedingly important that there should be systematic exploration at a distance from the shore both in winter and summer. This is one of the tasks proposed by the Commissioner of Fisheries for the new sea-going steamer now being constructed. Mr. Marcus A. Hanna, of Bowery Beach, Maine, states that he knows certain places on the coast of Maine where Cod are found in mid-winter not more than two miles from land, in water from *forty to fifty fathoms deep, and upon soft bottom. A portion of the Gloucester George's Bank* fleet continues fishing through the winter months, though at this season the vessels do not, as in spring and summer, fish upon the shallow parts of the bank, but rather seek the deep waters around its edge. The fish make their appearance, however, on the bank early in February.

An experimental cruise made in winter by Captain Mar throws some light on the movements of the Cod in this region: "One winter I started on a cruise before the time for the Cod to come, which was usually from February 7th to the 10th. I sounded all over the usual ground. None there. Cruised seventy-five miles to the south'ard, sounding in thirty to one hundred fathoms of water. Found none—only one Codfish. Got back to the banks and found the Codfish there." At another time he was going over the shoal ground of the banks in February, with a load of fish; in sounding, *passing over the shoals in sixteen fathoms of water, he caught six pairs of large fish. He thinks* that they were "solid," passing over the shoal. It should be borne in mind that these fish were

[1] *Hind, op. cit., pt. i, pp. 15, 16.*

caught on hooks fastened to the sounding-lead, which was thrown over while the vessel was in motion.

The remarks made in the previous section regarding the times at which Cod were present and absent on different parts of the coast should be understood as expressing the facts only in a general way. It is undoubtedly true that Cod may be found in greater or less numbers within reach of the land from Block Island to Newfoundland, and perhaps to Labrador, at all seasons of the year. South of Block Island, Codfish are very rarely noticed in summer, even in the deepest water frequented by the fishermen, though a few remain on the grounds in the vicinity of the islands during the whole summer.

In the waters from Cape Cod to Cape Ann, and perhaps a little farther to the north, we find the district in which the bathic migrations of the Codfish are least apparent, the periodical changes in depth being but slight from winter to summer—the fish being within easy reach of the fishermen at all seasons of the year. Even here, however, there is a great increment in their numbers in winter.

The statements which have been made regarding the periodical movements of the Cod I do not by any means consider satisfactory or final. These movements are the results of many influences, and no one yet understands how much weight to attach to the relative importance of these three influences, *i. e.*, (1) the direct effect of temperature upon the fish themselves; (2) the abundance of food, as affected by temperature and other causes; and (3) the direct relations between temperature and the reproductive habits of the fish. There is no more difficult problem in ichthyological science.

"The Codfish 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 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. . . .

"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 seventy to eighty 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 eighty or even ninety fathoms, and the catch averaged over two-thirds large; but in hand-lining from dories they seldom fish in over fifty and usually less than thirty-five 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."[1]

FOOD.—Codfish feed upon all marine animals smaller than themselves which are found in the same waters with them and are digestible. It would seem useless to give a catalogue of the species which have been discovered in their stomachs. For a long period of years, before our naturalists learned to use the hand-dredge, a favorite place in which to search for the rare invertebrates of the deep water was the fish-dealer's store, and from the stomachs of Codfish scores of shells new to science have been taken. Since the introduction of improved methods of deep-sea research this mode of collecting has been somewhat less prosperous, but even at the present time many important additions to zoölogy are yearly made by the aid of this omnivorous animal. In the Report of the United States Commission, Part I, pp. 516, 517, may be found a list of the species of mollusks obtained by Mr. J. Hammond Trumbull from Cod caught near Stonington, Connecticut, and this includes but a very small percentage of the number that has thus been observed.

Codfish swallow bivalve shells of the largest size, like the great sea clams, which are a favorite article of food on certain portions of the coast; for instance, in Ipswich Bay great beds of empty shells of the sea-clam, *Mactra ovalis*, may be found upon the bottom. These shells are "nested," the smaller inside of the larger, sometimes six or seven in a set, having been packed together in this compact manner in the stomachs of the Codfish after the soft parts have been digested out. Some of them had shreds of the mussels remaining in them and were quite fresh, having evidently been but recently ejected by the fish. In Dana's "Geology" are mentioned great banks of dead shells off the island of Grand Manan, which doubtless originated in the same manner. Mr. W. H. Dall found some similar beds on the coast of Alaska which he attributed to the walrus, but which are more probably the remains of mollusks eaten by the Codfish. They feed also upon crabs of all kinds, lobsters and star fish, and have been seen at the surface catching the potato beetles and "June-bugs" which have drifted out from the shore. It is said that they succeed occasionally in capturing a duck,[2] and that they vary their diet by browsing upon carrageen, or Irish moss, which grows on the ledges near the shore. In searching at the bottom for shells and worms, Codfish often pick up objects which can hardly be regarded as nutritious. A very amusing catalogue of such objects might be included in this chapter, in which would be enumerated articles such as scissors, brass oil-cans, potato parings, corn cobs, and head of a rubber doll. The finding of finger-rings and fragments of oil-clothing, and the heel of a boot, inside of a large Codfish has suggested the idea that sometimes they swallow the fishermen.

"A wedding ring which belonged to Pauline Burnam, an English lady who was lost in the steamship Anglo Saxon, wrecked off Chance Cove, N. F., in 1861, was lately restored to her relations by a St. Johns (N. F.) fisherman, who found the ring in the entrails of a Codfish. The lucky fisherman received a present of £50 for restoring the highly prized memento to the lady's son."[3]

Stones of considerable size are often found in their stomachs, and fishermen have a theory that this is a sign of an approaching storm and that the fish thus take in ballast to enable them

[1] EARLL: *loc. cit.*

[2] The Vineyard Gazette says that Mr. James Osborne took a Codfish on Wednesday, at the "South Side," which weighed over sixty pounds. On dressing it, two full-grown ducks (old squaws) were found in its entrails. They were quite fresh, having most of their feathers on.—Gloucester Telegraph, May 6, 1857.

[3] Boston Journal, July 6, 1871.

to remain at the bottom when the waters are troubled. It is more likely that these stones are swallowed on account of sea-anemones or other edible substances which may be attached to them, in just the same manner that the shells of mollusks are taken in for the sake of the nutritious parts which they contain.

It is believed that certain schools of Codfish feed almost entirely at the bottom, while others prey upon fish. The fishermen claim to be able to distinguish these two classes by their general appearance, the first being heavier, with shorter heads, blunter noses, and smaller fins, and frequently known as "grubbers" or "ground-keepers," while fish belonging to what are known as the squid school, the herring school, and the lant school, which are probably the same fish at different seasons of the year, are brighter-eyed, slenderer in form, with sharper head, and in every way better adapted for swift locomotion. On the coast of Labrador, as well as in Scandinavia, Codfish follow the schools of spawning capelin in to the shore and prey greedily upon them, and elsewhere, at other seasons, they feed with no less voracity upon other species of fish which may be schooling, and of which they destroy vast numbers, such as mackerel, menhaden, herring, alewife, salmon, sculpin, flounders, cunners, and haddock.

In November, 1877, Mr. Vinal N. Edwards found in the stomachs of Cod taken at Noman's Land many species of fish, some of which, like *Eumesogrammus subbifurcatus*, are found only at great depths, and others, like the two-spined stickle-back, *Gasterosteus biaculeatus*, and the little file-fish, *Monocanthus setifer*, must have been taken at the surface or near the shore.

On the Grand Banks, especially in shallow water about the Virgin Rocks, I have been told that they follow the lant to the surface, pursuing them with great fierceness. Along our northern coasts they replace, to some extent, the voracious bluefish and bonito of the South. Captain Atwood remarks that the amount of food which they consume is enormous, when the size of the fish is taken into account. He has seen them on the coast of Labrador, where the capelin were in great numbers, with their stomachs filled to the greatest possible extent, and capelin in their mouths which they were unable to swallow for want of room, and in this condition they were still biting at the hook. They even feed upon the young of their own kind. They are said to feed largely upon herring spawn, though they are not seen in great numbers, about the spawning grounds until the schools of parent fish have departed. The herring, also, is a favorite article of food, and when these fish approach the shores or are seen on the banks it is a very good sign that Cod will soon be abundant. Mr. Earll remarks:

"I am told that in the spring of 1879 an immense school of herring moved closely 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.

"About Provincetown the common squid sometimes appear in great numbers, and they are most vigorously preyed upon by the Cod."

The same accurate observer gives the following notes concerning their food while breeding:

"During the spawning season the Codfish 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 ten to fifteen pieces were frequently found, and in one case eighteen 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."

Capt. R. H. Hurlbert tells me that sometimes a school of Codfish will bite at night; these the fishermen call "*Night Cod.*"

In 1860 the schooner "C. C. Davis" caught one entire trip of fish on George's Bank all in the night, and there are other instances on record, though, as a rule, these fish feed only in the daytime.

REPRODUCTION.—Two important papers on the breeding of the Codfish have recently been printed in the Report of the United States Fish Commission. The first of these is a translation of a report by Prof. G. O. Sars upon the practical and scientific investigations concerning the Cod-fish of the Loffoden Islands, Norway, made during the years 1864–'69, in behalf of the Norwegian Government.[1] His observations are full of interest. He tells us how, from year to year, he observed the movements of the Codfish and studied out their spawning habits.

In 1864 he visited the Loffoden Islands, in January, February, and March. He observed the coming in of the fish, as they approached the coast, swimming up the fiords in large schools, and in the latter part of February, and from that time until the end of March, found the eggs in immense numbers floating at the surface.

In 1865 he reached the islands in the beginning of March and remained until the middle of May. He gathered the eggs as they floated at the surface, and hatched them out in glass jars. He also artificially impregnated the eggs and found that the period of incubation lasted eighteen days. He also observed a few very small young fish at the surface.

In 1866 he was on the ground on the 7th of May, and remained until July. This year he found great quantities of young Codfish—the largest being about one and a half inches in length—swimming under the jelly fish (which are so numerous in those northern waters), and also under other objects floating in the sea.

In 1867 he reached the islands late in July, and remained until the beginning of October, and succeeded in finding the young fish, two inches or slightly more in length, swimming near the surface in the "slicks," and also in the shallow inlets near the shores, in company with the young pollock, while the stomachs of all the larger Codfish and pollock taken in the neighborhood were full of them. He also found in the beginning of October many larger young Codfish, upwards

[1] United States Fish Commission, pt. v, pp. 565–661.

of four inches in length and about seven months old, as estimated, at the bottom, at a depth of several fathoms.

In 1868 he began his observations in November, and in November and December found young fish six or seven inches in length at a depth of eight to twelve fathoms, usually in the vicinity of steep ledges and rocks. This year he remained until March, and in February found great numbers of young Codfish, the average length of which was about one foot, at an average of twenty to thirty fathoms, on sandy bottom. "In the beginning," he remarks, "I thought that these must be two-year-old fish, but when I afterwards set my line in shallower places I also collected smaller fish, so that I soon had all the different grades of size."

This last visit extended over into the year 1869, and at the time of his departure the schools of spawning fish were again on the ground. He had thus traced the development of the Codfish throughout a period of twelve months, and had secured a very complete chain of evidence with which to bind together the isolated facts regarding the growth and habits of the young fish which had hitherto been or should hereafter be observed.

From 1870 to 1873 he continued his observations upon the young and adult fish, and in midsummer found Cod at a distance of twenty to thirty Norwegian miles from the shore, and at a depth of from one hundred to one hundred and fifty fathoms. These observations, as has already been remarked, are of the utmost importance, and the reports of Professor Sars are full of observations of the most suggestive kind concerning the food, the movements, and the general habits of the fish.

The other paper referred to, which is of equal value, is the report of Mr. R. E. Earll upon the natural history and artificial propagation of the Cod, as observed at the station of the United States Fish Commission at Gloucester, Massachusetts.[1] His remarks upon the reproduction of the Codfish are here quoted in full, with the single observation that no one has so carefully observed the spawning habits of any other species of fish.

"The Cod is 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 Codfish is the most prolific of all.

"The exact number of eggs in a female 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, representing various stages of growth from twenty-one to seventy-five pounds, was taken, and the eggs were estimated. Care was exercised that the series should contain only immature females, so that no egg should have been lost, and that all might be of nearly equal size. The ovaries were taken from the fish and their weight accurately ascertained; after which small quantities were taken from different parts of each and weighed on delicately adjusted scales, the eggs in these portions being carefully counted. The number contained in a given weight being known, it was easy to ascertain approximately the entire number for each fish.

"The results obtained are given in a table, quoted below, showing a twenty-one-pound fish to have 2,700,000, and a seventy-five-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.

"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 five to eight pound fish has eggs of the smaller size, while a twenty-five-pound one has them between an eighteenth and a seventeenth.

[1] Report of United States Commission of Fish and Fisheries, pt. 6, 1878, pp. 665–740.

"From weighing and measuring known quantities it is found that one pound avoirdupois will contain 190,000 of the smaller size, or that 1,000,000 eggs well drained will weigh about five 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 fifty-seven and three-quarters cubic inches, to contain a little less than 400,000, or that 1,000,000 will measure between two and a half and three 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 breaks through the shell of the egg that confines it, the fetal curve or crook is still quite noticeable, but it soon straightens, and is then about five-sixteenths of an inch in length. At this time the yelk-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 the Cod, 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 other 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, showing the last hatched of one season to be 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 Cape Ann to be December, the large number of young fry ranging from one and a half to three inches must have been hatched the previous winter, and were consequently about six months old. The large number of individuals having a length of nine to thirteen inches indicated the normal growth of those hatched a year earlier, or fish of eighteen months, to be ten to eleven inches, and their weight seven to eight ounces. The next group, or the fish thought to be thirty months old, measured from seventeen to eighteen inches, with an average weight of two to two and a quarter 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 twenty-two inches and weigh from four to five 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 three and a half and the smallest ripe female five pounds.

"Evidence is not wanting to show that a Cod spawns every year, and that it deposits 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 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 being connected with the general mass by a slender thread that expands into a delicate membrane containing minute and diffusely branched blood-vessels. This membrane envelops 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 the 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 shore-fish or ground-tenders landed 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, we 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 first of December fully fifty 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 first of February the fish in Ipswich Bay were found to average fully ninety 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 sixty per cent. were still green. By the middle of the month the females numbered about forty per cent., though over half had not commenced spawning. On March 13, three hundred fish from this school were opened, with the following results: Fourteen per cent. were spent males; fifty-three per cent. were ripe males; six per cent. were spent females; fourteen per cent. were females in various stages of spawning; and eleven 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 Codfish spawning through 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 a period of 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 was 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 at 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 they would come to have a bulk greater than the entire stomach cavity of the fish. The products of the ovaries of a seventy-five pound fish, after impregnation, would weigh about forty-five pounds and measure nearly seven gallons, equal to over half of either the weight or bulk of the fish.

"Another proof that the Codfish deposits its eggs gradually during a long period is seen in the fact that few can be taken from the fish at a 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 twenty-one pound fish at a single stripping. 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 of Cod 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 greater numbers of spawning females are taken with the trawl, which lies 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. 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. The oldest fishermen had not the slightest knowledge of this fact, but held to the theory 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.

"There are many ways in which the 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 drifted about by the winds and tides, they are often carried long distances from the spawning grounds into the little bays and coves, and are driven in immense numbers upon the shores, or are 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 sweep with unbroken force across its surface, 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. One day in January we placed a jelly-fish or medusid, having a diameter of but one and a half inches, into a tray of eggs in the hatching-room, and in less than five minutes it had fastened seventy eggs to his tentacles, loading some of 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 frequently found upon the eggs, in one case forty-six being counted on a single egg. In addition a peculiar growth, thought to be minute algæ, was often noticed upon them. Just what influence these 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."

In the winters of 1878–'79 and 1880–'81 the United States Fish Commission successfully carried on the work of artificial propagation of Codfish. The results of the first winter's work at Gloucester will be found detailed in Mr. Earll's paper, from which quotations have already been so extensively taken.

In addition to his other observations, Mr. Earll computed the number of eggs in Codfish of different sizes. The results of his observations are shown in the following table:

Table showing the number of eggs in Codfish 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	1,198	160	9,100,000
1 (a)[1]		70–75	8 8	6	8 2	7	1,132		
2[2]	4 2½	51	7 2	5	6 13	6	1,131	188.5	8,989,094
3	3 8	30	2 8¾	2¾	2 6	6	1,341	223.5	3,715,687
4	3 5	27	2 9¾	2¾	2 7	7	1,680	240	4,095,000
5	3 4½	22¾	2 2⅝	2	2 0¾	6	1,368	228	3,229,388
6	3 3	21	1 15¾	1¾	1 14	6	1,249	208.17	2,732,237

[1] 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.

[2] No. 2 contained a few ripe eggs.

It is interesting to compare these with the observations made during the last century, references to which may be found in all the standard works on natural history. Leuwenhoek is said to have found in a Cod of middling size 384,000 eggs. Harmer found, in one weighing eighteen or twenty pounds, between 3,000,000 and 4,000,000 eggs. It was examined December 23, and was estimated to have 294 eggs to the grain, the ovaries weighing 12,540 grains; the total number, according to this calculation, is 3,686,760.[1]

THE SIZE OF CODFISH.—The result of Mr. Earll's observations indicates that in June the fish hatched the previous winter, or about six months old, range from one and a half to three inches in length; while those from nine to thirteen inches long, and weighing seven or eight ounces, were eighteen months old; those seventeen to eighteen inches long, and weighing two to two and a quarter pounds, were supposed to be two years and a half old; those of about twenty-two inches, which weighed four to five pounds, were three years and a half old. He also concludes that the male reaches maturity at the age of three, and the female at the age of four years, for the smallest ripe male noticed during the season of 1878–'79 weighed three and one-half pounds, and the smallest ripe female five pounds.

On pages 733–734 of Mr. Earll's report may be found the measurements of a large number of Codfish of different weights, and with the ovaries and spermaries in different stages of development. These measurements are interesting, since they show the relation between the length and weight of individual fish.

I have before me memoranda relating to a large number of enormous Codfish, taken along the New England coast at various times from 1830 to 1879. It seems unnecessary to refer to them, excepting the cases of a few which exceed one hundred pounds in weight.

Capt. King Harding, of Swampscott, tells me that he once caught, on the eastern side of Cape Cod, a fish weighing 101 pounds as it came from the water.

On the 22d of July, 1873, Miss Fannie Belis, of Saint Louis, while on a fishing excursion off Eastern Point, on board the yacht "United States," caught a Cod which weighed 130 pounds.

Capt. G. H. Martin caught, off Chatham, a Codfish which weighed, dressed, 111 pounds.

Capt. Stephen Mar, of Gloucester, saw a Codfish taken on George's Banks in 1838 which, after having been eviscerated, weighed 136 pounds.

Captain Atwood says, on the coast of Cape Cod he has never seen a male Codfish, with one exception, which weighed more than 60 pounds; he once saw one, however, which weighed 160 pounds. This fish was not much larger than an ordinary fish weighing 75 pounds, but was very *thick.*

Captain Atwood remarks: "In regard to size, the Cod differs very widely in different localities. When taken on the Grand Bank it usually requires from thirty to forty to make a quintal when dried. Those caught in the Gulf of Saint Lawrence with hand-lines are smaller, requiring seventy to eighty per quintal; in the same locality, however, Cod caught on trawl-lines require *only twenty to twenty-five per quintal, while on the coast of* Labrador they are all small, and it requires about one hundred to one hundred and ten to make a quintal."

Writing in the summer of 1877, Captain Atwood expressed the opinion that the average weight of the fish taken about Cape Cod was in the neighborhood of ten pounds; but he informed me that in the winter of 1877, in two days, thirty thousand pounds of Codfish were landed from the boats, and that there was not a fish among them small enough to be classed as a market Cod, a market Cod weighing from six to ten or twelve pounds.

[1] Philosophical Transactions, lvii, 1778, p. 287.

I have before me much information concerning the average size of the fish caught at different seasons of the year by the fishermen at different localities along the coast, but it seems at present hardly necessary to discuss this subject at greater length.

CONCLUSIONS AS TO DECREASE OF COD FISHERIES ON THE NEW ENGLAND COAST.—In conclusion, it may not be amiss to quote the remarks of Professor Baird concerning the decrease of Codfish along our coast, and the probable causes for such decrease:

"Of all the various fisheries formerly prosecuted directly off the coast of New England, north of Cape Cod, the depreciation in that of the Cod appears to be of the greatest economical importance. Formerly the waters abounded in this fish to such an extent that a large supply could be taken throughout almost the entire year along the banks, especially in the vicinity of the mouths of the larger rivers. At that time the tidal streams were almost choked up with the alewives, shad, and salmon that were struggling for entrance in the spring, and which filled the adjacent waters throughout a great part of the year.

"As is well known, the erection of impassable dams across the streams, by preventing the ascent of the species just mentioned to their spawning grounds, produced a very great diminution, and almost the extermination, of their numbers; so that whereas in former years a large trade could be carried on during the proper season, now nothing would be gained by the effort.

"Of late the attention of the legislatures of the New England States has been called to this fact, and to the importance of restoring their fisheries, and a great deal has been already accomplished toward that end. Unfortunately, however, the lumbering interest in Maine, and the manufacturing in New Hampshire and Massachusetts, are so powerful as to render it extremely difficult to carry out any measures which in any way interfere with their convenience or profits; and notwithstanding the passage of laws requiring the construction of fishways through the dams, these have either been neglected altogether, or are of such a character as not to answer their purpose. The reform, therefore, however imperatively required, has been very slow in its progress, and many years will probably elapse before efficient measures will be taken to remedy the evils referred to.

"It would, therefore, appear that while the river fisheries have been depreciated or destroyed by means of dams or by exhaustive fishing, the Codfish have disappeared in equal ratio. This is not, however, for the same reason, as they are taken only with the line, at a rate more than compensated by the natural fecundity of the fish. I am well satisfied, however, that there is a relation of cause and effect between the present and past condition of the two series of fish; and in this I am supported by the opinion of Capt. U. S. Treat, of Eastport, by whom, indeed, the idea was first suggested to me. Captain Treat is a successful fisherman and dealer in fish on a very large scale, and at the same time a gentleman of very great intelligence and knowledge of the many details connected with the natural history of our coast fishes, in this respect worthily representing Captain Atwood, of Provincetown. It is to Captain Treat that we owe many experiments on the reproduction of alewives in ponds, and the possibility of keeping salmon in fresh waters for a period of years. The general conclusions which have been reached, as the result of repeated conversations with Captain Treat and other fishermen on the coast, incline me to believe that the reduction in the cod and other fisheries, so as to become practically a failure, is due to the decrease off our coast in the quantity, primarily, of alewives; and, secondarily, of shad and salmon, more than to any other cause.

"It is well known to the old residents of Eastport that from thirty to fifty years ago Cod could be taken in abundance in Passamaquoddy Bay and off Eastport, where only stragglers are now to be caught. The same is the case at the mouth of the Penobscot River and at other points along

the coast, where once the fish came close in to the shore, and were readily captured with the hook throughout the greater part of the year. That period was before the multiplication of mill-dams, cutting off the ascent of the alewives, shad, and salmon, especially the former. The Saint Croix River was choked in the spring with the numbers of these fish, endeavoring to ascend; and the same may be said of the Little River, the outlet of Boynton's Lake, about seven miles above Eastport. The lake in question is one of considerable size, and was visited by immense numbers of alewives, which could be dipped out, to any extent, on their passage upward, while the waters of the adjacent bay were alive with the young fish on their return.

"The fish themselves enter the waters of the streams in May or June, and return almost immediately after spawning to the sea. But they may be taken by the drift-nets along the shores as early as March and April; and, indeed, it is quite probable that the whole period of their abode in the salt water is spent adjacent to the rivers in which they were born. The young come down from the ponds in which they are hatched, from August to October, keeping up a constant stream of the young fish. In this way a supply of alewives was to be met with throughout the greater part of the year, and nearer the coast they furnished every inducement for the Cod and other ground fish to come inshore in their pursuit.

"It is true that the sea-herring is also an attraction to these fish, and probably but for their presence our pollock, haddock, and hake fisheries would be greatly diminished. Nevertheless, the alewife appears to be more attractive as a bait, and furthermore the sea-herring are less constantly on the coast, especially inshore, occurring as they do at stated intervals, when they come in from the deep sea to spawn. It is possible, too, that they are less easily captured by the Cod, since they swim nearer the surface than the alewives. Corroboration of this idea is furnished in the testimony of Mr. W. B. McLaughlin, of Southern Head, Grand Manan. This gentleman informs me that the only stream in the island which ever furnished alewives to any extent was Seal Cove Creek, which discharges to the east of the southern extremity of Grand Manan, and into which these fish entered in immense numbers in the spring. At that time Cod, Haddock, and Pollock, as well as halibut, were taken in great abundance in Seal Cove Sound, between Harwood Cove, on Wood Island, and Indian or Parker's Point, on the main island. They were to be met with during the greater part of the year, especially from May to January; and the fishery in the channel-way within a quarter of a mile of the shore was really more productive than on the banks much farther out to sea.

"Although still a young man, Mr. McLaughlin recollects the capture of these fish; and, indeed, as a mere boy, enjoyed the sport within a very short distance of his father's house. Soon after that time a dam was built across this stream about two hundred yards above its mouth, cutting off entirely the upward passage of the alewives, and by a remarkable coincidence, if it be nothing more, the cod fishery in question diminished very soon after, and in a very few years ceased almost entirely, so that up to the present time there are not enough Cod in those waters to repay the experiment of attempting to catch them. A few alewives still find their way up to the foot of the dam, but in such small numbers as to make it often doubtful whether there are any there or not.

"The other fishing grounds about Grand Manan are farther out to sea, at the northern end of the island, where there are no alewives, and where herring appear to be the principal food, although the variation in the abundance of these in different seasons appears to have an important bearing upon the number of Hake and Cod.

"If these conclusions be correct—and I am quite satisfied of their general validity—we have, for the efforts made to establish fishways in the rivers of Maine, New Hampshire, and

Massachusetts, a much more weighty reason than that of merely enabling a few salmon to enter the streams in order to permit their capture while on their way.

"Whatever may be the importance of increasing the supply of salmon, it is trifling compared with the restoration of our exhausted cod fisheries; and should these be brought back to their original condition, we shall find, within a short time, an increase of wealth on our shores, the amount of which it would be difficult to calculate. Not only would the general prosperity of the adjacent States be enhanced, but in the increased number of vessels built, in the larger number of men induced to devote themselves to maritime pursuits, and in the general stimulus to everything connected with the business of the seafaring profession, we should be recovering, in a great measure, from that loss which has been the source of so much lamentation to political economists and well-wishers of the country."

66. THE TOM CODS. MICROGADUS TOMCOD AND M. PROXIMUS.

THE ATLANTIC TOM COD.—The Atlantic Tom Cod, *Microgadus tomcod*, is found only in the Western Atlantic, ranging from New York at the south to Cape Sable at the north. It is ordinarily known as the Tom Cod, but in the Bay of Fundy, and in various places south of Cape Cod, it is known as the Frost Fish, owing to the fact that it becomes most abundant in the early part of the winter, when it approaches the shore and even ascends the rivers and creeks for the purpose of spawning. Dr. DeKay states, on the authority of Dr. Yates, that Tom Cods sometimes appear at Albany in abundance, while I am informed by the Rev. Dr. F. Gardiner that they are taken in winter in the Kennebec, sixty miles from its mouth, and far above the reach of the tide. They ascend the Charles River to Watertown, where they are taken in dip-nets and by the hook from the wharves and bridges. Although most abundant near the shores and in the streams in early winter, they are found along the coast at all seasons of the year. In form the Tom Cod is the miniature of the Codfish, rarely exceeding ten or twelve inches in length, and there is much difficulty in distinguishing the young of the two species. The Tom Cod, however, varies even more in its color than the Cod, and several varieties have been described under different names. When these fish approach the shores in winter they are taken in great quantities with nets, and are esteemed in many localities as a great delicacy.

The Tom Cod feeds upon numerous species of crustaceans and mollusks, and also upon the young of many other kinds of fishes.

THE PACIFIC TOM COD.—Professor Jordan gives the following notes upon the closely related species, *Microgadus proximus*, found in California, and there known as the Tom Cod:

"The English at Victoria know this species by the name 'Whiting.' Elsewhere on the coast the name of 'Tom Cod' is universally applied to it. In the restaurants at San Francisco, it is usually served under the name of Smelt. It reaches the length of a foot and a weight of about half a pound. It ranges from Monterey to Puget Sound and northward, being everywhere very abundant, and taken in great numbers in seines and sweep-nets, both outside and in the bays. Its food is small fishes. Nothing special is known of its breeding habits; it is apparently abundant at all seasons. It is one of the important food fishes of the coast, always abundant and always meeting a ready sale. Its flesh is, however, watery and tasteless, and cannot be rated high."

67. THE HADDOCK. MELANOGRAMMUS ÆGLEFINUS.

DISTRIBUTION.—The Haddock, *Melanogrammus æglefinus*, is found only in the Atlantic. Its wanderings are more limited than those of the Cod. It is not found nearly as far to the north; while its southern range is no wider. Haddock are probably found in company with Codfish on all

the northern fishing grounds, as far south, at least, as the Capes of Delaware, though concerning their occurrence in southern waters there is dearth of information. In winter and spring they are taken in Fisher's Island Sound and outside of Fisher's Island, on the coast of Eastern Connecticut; and also in great quantities on Nantucket Shoals by the smacks, and are carried thence with Cod into New York market. In 1871 it was estimated that the catch of Haddock here was nearly equal to that of Cod, although the latter usually predominate. They abound north of Cape Cod, in the Gulf of Maine, and in the Bay of Fundy, in the Basin of Minas, on the coast of Nova Scotia, in the Gulf of Saint Lawrence, and in the Bay of Chaleur. In the Gulf of Saint Lawrence, according to Captain Atwood, they are not very abundant, but the individuals taken are very large. They are taken on the western coast of Newfoundland in winter; their northern limit appears to be marked by the Straits of Belle Isle, latitude 52° N. The researches of Dr. A. S. Packard on the coast of Labrador failed to bring this species to light, and fishermen of that region told him that in the course of forty years' experience thay had never seen a Haddock. In 1863 and 1864 they were found in abundance on the southern border of the Grand Bank. Capt. R. H. Hurlbert states that he has seen them in great abundance in May at Louisburg, Cape Breton, playing at the surface among the reefs, but that they are not so frequent on the Grand Bank as on the Western Bank, and, in turn, less common there than on George's Bank.

In the Eastern Atlantic the range of the Haddock is somewhat wider, for they are found in the seas of Iceland, the whole length of the Scandinavian coast to East Finmark and Varanger Fjord, and on all the shores of Great Britain, and in the North Sea, where they are particularly abundant, though rarely or never entering the Baltic. There is no evidence that they are found to the south of the English Channel. De La Blanchère states that they are caught in considerable numbers on the coast of Manche. In the Eastern Atlantic, then, they are found between the parallels 48° and 66°; in the Western Atlantic between the parallels 38° and 53°.

NAMES.—The Haddock is often called "Dickie" by Connecticut fishermen. Hadot and Hadou are old French names for the same fish, though the species is now usually known by the name Égrefin. In Scotland the name is said to be pronounced almost in the same way as in France, and is often varied to Haddie. It is the Schellfisch of Germany. Concerning this fish many of our fishermen entertain the same idea, which with them can hardly be called a superstition, that the black spots upon their side are due to the impression of the thumb and finger of Saint Peter when the apostle took the tribute money out of the mouth of a fish supposed to be of this species, the fisherman's mark having been continued among its descendants ever since. This notion is prevalent also in England, and in Southern Europe is attached to other fishes, particularly to the John Dory, *Zeus faber*. It is needless to say that no member of this family occurs in the Sea of Galilee.

MOVEMENTS.—Haddock are not so active and powerful as the Cod. Dr. Gilpin has expressed the opinion that on the coast of Nova Scotia they do not retreat so far from the shore in winter as the Cod, but this does not appear to be true in Massachusetts Bay.

Storer, in 1839, made the assertion, which was repeated in 1867, in another edition of the "History of the Fishes of Massachusetts," that in Massachusetts Bay in the warm season about twelve hundredweight of Haddock are taken to each hundredweight of Codfish, and in the winter about twelve hundredweight of Cod to each hundredweight of Haddock; but since the haddock fishery is of longer duration, the proportion throughout the year averages about three Haddock to one Cod. They abound in Massachusetts Bay throughout the summer, and it is at this season also that they are taken in the greatest abundance on the off-shore banks in the Gulf of Saint Lawrence.

There is a strange absence of information concerning their movements on the European coast. On the coast of East Friesland the haddock fishery is permitted by law from March to the begin-

ning of June, and from October to the middle or end of January, a winter recess being allowed for the purpose of spawning. It is stated by Dr. Wittmack that during the heat of summer they retreat from these coasts, with the Cod and the flounder, into the deepest waters, appearing again towards the end of September. On the coast of Scotland they are said to be most abundant in winter. In Massachusetts Bay, as it has been said, they are most abundant in summer, coming in after the cod pass out, though they are also taken in deeper parts of the bay the whole winter long, and are sought at this season on George's and other off-shore banks as well as localities farther to the north.

A study of such data as these is unsatisfactory in the extreme, since it is impossible to draw from them any conclusions concerning the relation of the movements of the Haddock to the temperature of the water in which it is found. The only movements which are now intelligible are those which take place at the period of spawning.

ABUNDANCE.—Remarkable variations in the abundance of this fish are upon record; at certain times they have been exceedingly rare, at others abundant in the extreme. They appear to be much more gregarious than the Codfish, and to swim together in large schools from place to place. Storer, writing in 1839, said that they were common about Cape Cod, but that ten years before they had been rare. An item in the "Gloucester Telegraph," June 3, 1837, stated that Haddock were at that time brought in abundantly and sold from the Swampscott boats at a cent apiece.

According to Capt. E. W. Merchant, in the years from 1814 to 1820 there was a great catch in the vicinity of Nahant, about five miles at sea, east-southeast. So plenty were they that two men and one boy could catch with hand-lines from one boat 600 to 1,000 in number in one day. This school of fish came in about the 20th of March and continued until the first of May, then gradually decreased and spread over the fishing banks in Massachusetts Bay. At this time the majority of the boats belonged to Sandy Bay, now Rockport, and to Gloucester.

Capt. King Harding, of Swampscott, tells me that in 1843 Haddock were so scarce that they were sold singly. The fishermen received twenty-five cents each for all they could get. A vessel could not get more than one hundred in the course of a day's fishing.

At this time Isaac Rich & Co. chartered the schooner "Harriet," of Duxbury, to go out on a special cruise for Haddock, paying $200 toward the venture. She started out with a crew of five men about the 20th of February, and fished on soft bottom in the deepest water. Her fare was two hundred and twenty Haddock, and the trip was considered a remarkable success.

In May of the next year great schools of little Haddock came in. They were six or eight inches long and a great bother to the fishermen. The following year they were about half grown, or a foot or so in length and very thick. They came in May.

In 1846 they came in earlier, many in March, but mostly in May. They were quite large and very abundant.

Haddock were also very abundant in 1857. On the 13th of March one hundred Swampscott fishermen, in twelve vessels, caught in a period of about six hours 160,000 pounds of fish, chiefly Haddock.[1]

In 1877 and 187° .ne Haddock were very large and quite scarce. In the winter of 1877 and 1878 they were larger than for many years. Some were caught near Swampscott which weighed fifteen and sixteen pounds. The average size is from four to six pounds.

Captain Atwood states that in 1834 Haddock were very scarce on the Grand Bank, and few were caught anywhere on the coast, but in 1840 they became so numerous about Cape Cod as to interfere seriously with the cod fishery, devouring the bait before the Cod could reach it, and about 1850

[1] LEWIS: History of Lynn, p. 450.

they had increased so rapidly that the markets were glutted. In 1864 they were caught in great numbers and were still on the increase. In 1870 the same observer related to the Massachusetts senate the story of another period of scarcity and abundance. His statements may be found in the Report of the United States Commission of Fish and Fisheries, part 1, 1873, p. 119. He elsewhere says:

"If over-fishing were possible, it seems to me that we should see some of its results where great changes have taken place in the modes of our fisheries of Cod and Haddock in Massachusetts Bay. What is called 'trawl fishing' was first introduced about 1850, and it resulted in the taking of a vast number of fish of these varieties. In consequence of the competition in the business, the Swampscott people petitioned the legislature for a law prohibiting trawl-fishing, on the ground that it would exterminate the Haddock. At that time I proved before the legislature that Haddock was much more abundant than it had been at any previous time, and that I was selling them at thirty-seven and a half cents per hundred pounds. That fishery has been going on ever since, and the amount taken was greater this last winter than for many years past. A fisherman in a dory fifteen feet long has often brought in as much as 1,800 pounds in a single day. There are eighty boats fishing out of the harbor, and 83,000 pounds have been caught in one day. This increase has taken place in spite of the constant practice of the new mode of fishing, by which twice as many are taken in the same time as formerly."[1]

Captain Atwood explains the great increase at this time by the introduction of fishing with long trawl lines, which destroyed many species of fish preying upon haddock spawn. At the present time Haddock are very abundant; they are caught throughout the summer in great numbers by the Irish market-boats of Boston, and in winter a large fleet of Gloucester and Portland vessels are engaged in catching them upon George's and other off-shore banks. These vessels fish with trawl lines, and it has been stated that a single crew has been known to take nearly 60,000 pounds in a day.[2]

FOOD.—The food of the Haddock resembles that of the Cod, except that they are, if possible, more omnivorous; their diet consists, however, largely of invertebrates. They are rarely seen feeding at the surface, though they devour the spawn of other fishes, particularly that of the herring, with great eagerness. They devour great quantities of shells, many of them of the burrowing species. Professor Verrill has well said that a complete list of the animals devoured by the Haddock would doubtless include all the mollusks belonging to the fauna of New England.

The Haddock are said to be particularly abundant on clam-banks. From this habit of feeding on shells has originated the German name for the fish. The difference between the habits of the Haddock and the Cod is illustrated by the remark of Captain Atwood that Haddock will take a baited hook as it rests upon the ground, while the Cod will only notice it when it is raised a short distance from the bottom. Salted menhaden is a favorite bait for Haddock, but not desirable for Cod, while both Cod and Haddock will readily take stale clams, which are much better for bait than fresh ones.

REPRODUCTION.—The spawning habits of the Haddock in our waters have been carefully observed by Mr. Earll, whose statements are quoted below: On the German coast the Haddock spawn on rocky bottoms in February and early March at a depth of twenty-two to twenty-five fathoms;[3]

[1] Extracts from Captain Atwood's manuscript biography.

[2] BIG HADDOCK TRIP.—Schooner "E. L. Rowe," of this port, Capt. Sewell W. Smith, arrived from George's on Monday at Boston, with 70,380 pounds of Haddock, the largest trip ever landed. Time absent, five days. The largest trip previous to this was landed by the same skipper in schooner "Cora E. Smith," 52,679 pounds, February 13, 1877. In February of the same year, schooner "Paul Revere," Capt. John Bentley, landed 51,700 pounds of Haddock and 2,500 pounds of Codfish as the result of one day's fishing.—*Cape Ann Advertiser*, February 21, 1878.

[3] WITTMACK, L.: Beiträge zur Fischerei-Statistik des Deutschen Reichs, 1875, p. 25.

and according to Yarrow the spawning period is the same on the British coast, the young growing to a length of six or seven inches before the beginning of September. At the Loffoden Isles, according to Sars, the spawning season of the Haddock takes place a little later, beginning toward the end of February and being at its height late in March.[1]

Mr. Earll's observations are as follows:

"The fish usually remain on the off-shore 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 individuals, 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 daily. 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 one 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), 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."

Mr. Earll's observations confirmed those of Professor Sars, that the spawn of the Haddock floats at the surface like that of the Cod, and that the spawning process is in every way similar. The following table gives the result of his enumerations of the number of eggs in Haddock of different sizes:

Table 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	28½	9 5/8	9½	⅛	8⅜	4	1,950	487.5	1,839,581
2	28½	6 13/16	5⅞	⅛	5¾	4	1,479	369.75	849,315
3	26	6 5/16	6¼	¼	6	4	1,457	364.25	856,156
4	24	4 13/16	5⅜	¼	6¼	5	1,160	232	634,380
5	23	4	5¼	¼	4¾	5	970	194	403,132
6	20½	3 7/16	5¼	¼	4¾	5	960	192	398,976
7	19½	2 1/16	2⅜	⅛	2	5	966	193.2	169,050

[1] Report of the United States Commission of Fish and Fisheries, part 5, 1879, p. 586.

The average size of the Haddock is probably not far from three or four pounds; many twelve-pound fish are brought to market, and individuals weighing seventeen pounds are on record.

In 1879 Haddock were successfully hatched, under the supervision of Mr. Earll, at the Gloucester station of the United States Fish Commission.

USES.—The Haddock is now very highly esteemed as a food fish, having grown in favor during the last twenty years. It is especially desirable for boiling or for making chowders, and is a great favorite in Boston, while in Philadelphia enormous quantities are yearly consumed. Being well adapted for preservation in ice, great numbers of them are distributed through the interior of the country, together with the Codfish. The success with which the Scotch method of smoking Haddock has been introduced into this country has also greatly increased the demand for them, and Finland Haddies are manufactured in enormous quantities in Portland and Boston. At Provincetown a Haddock salted and dried after being split is called by the name "Skulljoe," or "Scoodled Skulljoe."

68. THE POLLOCK. POLLACHIUS CARBONARIUS.

The Pollock, *Pollachius carbonarius*, which is the Coalfish of England, the Köhler of Germany, and the Sei of Norway and Sweden, is closely related to the Pollack of Great Britain, *Pollachius virens*, from which, however, it is specifically different. It is one of the best-known fishes of Northern Europe, as may be inferred from the abundance of its common names. The following names are in use in different parts of England: Baddoch, Billet, Billard, Black-Pollock, Black-Jack, Black-Coalsey, Blockan, Blockin, Coal, Coal-fish, Coalsay, Coalsey, Coal-Whiting, Colemie, Colmey, Cooth, Cudden, Cuddy, Dargie, Gilpin, Glassock, Glashan, Glossan, Glossin, Green-Cod, Green Pollock, Grey-lord, Gull-fish, Harbin, Kuth, Lob, Lob-Keling, Maulrush, Parr, Piltock, Podley, Poddlie, Podling, Pollack, Prinkle, Rauning Pollack, Rawlin Pollack, Rock Salmon, Raw Pollock, Saithe, Sethe, Sey, Sey Pollack, Sillock, Skrae-fish, Stenlock, Tibrie.

DISTRIBUTION.—Its geographical distribution is quite different from that of either the Cod or Haddock, its northern range, at least in the Eastern Atlantic, being fully as wide as that of the Cod, the species having been found in the northern part of Spitzbergen, beyond the parallel of 80°, and on the arctic coast of Europe. It rarely enters the Baltic. Bloch records a specimen from Lubeck, and it is said to occur on the coast of Pomerania.

Concerning the limits of its southern range authorities differ. Günther places this at latitude 46° in the Bay of Biscay, while others claim that it enters the Mediterranean. Canestrini states that it has been observed at Taranto.[1] It does not appear, however, that the species is abundant south of the English Channel. It occurs about Iceland and on the west coast of Davis Straits, where specimens were obtained by Sir Edward Parry on his first voyage. North of Newfoundland it does not seem to be very abundant, while to the south the limit appears to be in the vicinity of Nantucket Shoals, where specimens are occasionally taken by the cod smacks.

In Perley's "Catalogue of the Fishes of Nova Scotia," he states that he had never seen the fish in the Gulf of Saint Lawrence, nor heard of it except near the Straits of Canso, although it was found very abundant in the Bay of Fundy and everywhere except in the muddy waters, such as those of Cumberland Bay and the Basin of Minas.

I have seen large individuals taken in midsummer in the pounds in Vineyard Sound, and the capture of small individuals in these waters is not unusual. They are often taken, according to De Kay, off New York, in company with the Cod. In June, 1881, the schooner "Edward E. Webster," of Gloucester, Solomon Jacobs, captain, returning from a southern mackerel trip, fell in

[1] CANESTRINI: Fauna d' Italia. Peschi, 1872, p. 155.

with a school of Pollock and captured sixty thousand pounds of them in her purse seine. Its range, as now understood, is in the Eastern Atlantic between the parallels 46° and 80°, in the Western Atlantic between 40° and 70°. That its southeastern limit is as near the equator as the parallel of 36° seems quite improbable.

HABITS AND FOOD.—Unlike the Cod and the Haddock, the Pollock is, to a great extent, a surface-swimming species. The fishes of this species congregate together in large schools, roaming from place to place in search of food. To a certain extent they feed at the bottom, like Cod, but are more often seen at the surface of the water, where they prey upon young fish of all kinds.

Professor Sars gives the following account of the manner in which they prey upon little Codfish:

"I was much interested to see how the Pollock caught the young Codfish. It looked like a systematic chase, and it certainly looked as if the Pollock were acting with a common and well-defined purpose. As far as I could observe, the schools of Pollock surrounded the little Codfish on all sides, making the circle constantly narrower until all the Codfish were gathered in one lump, which they then, by a quick movement, chased up to the surface of the water. The poor little fish now found themselves attacked on all sides: below, the voracious Pollock, which in their eagerness often leaped above the water; and above, hundreds of screeching sea-gulls, which, with wonderful voracity and precision, pounced down upon the places where the Pollock showed themselves, to share the spoils with them. The whole chase is carried on so rapidly, and the young fish stay only so short a time at the surface of the water before they are scattered in all directions with lightning-like rapidity, that it was not even possible for me to see any, much less to catch any with my insufficient implements."[1]

On the coast of New England they are much disliked by the fishermen, who claim that they consume great quantities of other fish much more valuable than themselves; in consequence of this the fishermen have a great prejudice against them and refuse to eat them.

Captain Atwood states that about Cape Cod they do not take to the hook freely; that in other localities they are exceedingly voracious, and great numbers of them may be caught in Massachusetts Bay with a surface bait.

When the United States Fish Commission steamer has been stationed north of Cape Cod, a favorite amusement of the officers has been to catch young Pollock with a fly. The older fish are less active and remain more at the bottom.

MOVEMENTS.—Concerning this species, Captain Atwood states that they appear about Cape Cod in schools in early May, frequently passing round Race Point so closely to the shore as to be caught with the seine among the "tide-rips."

Capt. E. W. Merchant, of Gloucester, tells me that the Pollock were very abundant in Massachusetts Bay early in this century—before the war of 1812. They were especially abundant on Middle Bank. They were at that time chiefly caught with bait of herring, taken in seines from the beaches. The fishing boats were of about thirty tons, and carried three men and a boy. Fishing was carried on chiefly at night, when the vessels would all "fleet up," and the bait on their hooks would toll the schools of fish together. The vessels would take about fifty quintals in a night. There were about thirty fish to the quintal. This abundance of Pollock lasted until about 1820. These Pollock were salted, and consumed at home or carried to Maine. They sold for about two dollars a quintal. The oil of their livers was tried out in kettles on the shore. Their roe was exported largely in those days. It was sold by the bushel, at the rate of about sixty cents.

[1] Report of the United States Fish Commission, part 5, 1879, p. 593. Another vivid description of the manner in which the Pollock feed upon the sand-eels, or lant, may be found on pp. 619 and 620.

Mr. Earll writes:

"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.[1] 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 thirty cents per one hundred pounds. The average weight of the fish is about nine or ten pounds, and during the spawning season the sexes are taken in about equal numbers."

Early in May, 1881, two vessels at Chatham caught in one day 35,000 pounds each. The fish were caught with seines as they schooled at the surface like mackerel.

Perley, writing in 1851, mentioned that he observed that a large number of small fishing schooners was engaged in the capture of Pollock in the rips, or riplings, off Grand Manan. "These rips are formed by strong currents and the conflict of tides, in which the lively Pollock delight to play. Here there is found an abundance of small herring for food. For this description of fishing the vessels are kept in easy sail, the lines attached to poles of seven feet in length, which project from the sides of the vessel. A round, bright lead is used, about seven inches in length, weighing from one-half pound to one and one-half pounds; the bait is a piece cut from the under, or bright, side of the Pollock; it is called the 'last'; this, being kept in brisk motion by the sailing of the vessel, closely resembles the living fish darting through the water, and is eagerly chased by the Pollock. The fishers often take twenty Pollock with a single 'last,' it being a very tough bait."

In the Bay of Fundy and along the coast of Maine the capture of young Pollock from the rocks is a favorite amusement. At Eastport these fish are often called "Quoddy Salmon." Hind states that in the Gulf of Saint Lawrence they are known as "Sea Salmon"; this name may refer both to their active and voracious habits, and to the excellence of their flesh in those localities.

The capture of young Pollock, or mort, on the coast of Norway, is described by Sars in the paper already referred to.[2]

REPRODUCTION.—The spawning of the Pollock occurs in the German Ocean, according to Wittmack, from December to February; in Scotland, according to Parnell, in February, after which it remains out of condition until May.

About the Lofodens, as indicated by the observations of Sars, the breeding time corresponds with that of the Codfish, the young Pollock being found in early summer in company with the young Cod, swimming under the protection of the jelly-fishes.

Mr. Earll found Pollock spawning at Cape Ann in November and December, but he does not state whether the breeding season continued through the winter and early spring. Concerning the observations made at the Gloucester station, he writes:

"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

[1] In 1881 the first Pollock came into Gloucester Harbor May 2.

[2] See Report of the United States Commission Fish and Fisheries, part 5, p. 720.

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.

"The table gives the result of our computation of the number of eggs in individuals of different size, from which it will be seen that a twenty-three and one-half pound fish has over 4,000,000 of eggs, while a thirteen-pound one has 2,500,000."

Table 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 (fry) 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 3½	23½	2 2	2	2 0	6	1,727	287.8	4,029,200
2	2 8½	13	1 2¾	1¼	1 1½	6	2,043	340.5	2,569,753

Captain Atwood states that in Cape Cod Bay they are caught in large numbers about the 10th or 15th of November, when going to spawn. They spawn upon the same rocky ground as the Cod, and it is only at this time that they dare to take the hook freely. In the vicinity of Provincetown the deposition of eggs takes place in November.

The growth of the Pollock is probably somewhat more rapid than that of the Cod, since the young fish are so much more voracious, but we have no means of determining the length of time required for them to attain maturity. The average size is probably not far from ten or twelve pounds, but individuals of twenty, and even of thirty pounds, are by no means uncommon.

USES.—The Pollock is one of those species whose value as an article of food is very much underestimated. Many persons, who have investigated the subject accurately, prefer salted Pollock to salted Codfish, although the flesh is not so white. Its value for use in the fresh state, we think, deserves the highest commendation. I quote from "Land and Water," December, 1866, the following remarks upon the Pollock fisheries of the Orkney Islands, showing how highly they are esteemed in that region. The writer signs himself "A. R. D.":

"Having observed in 'Land and Water,' of the 20th October, an article by Mr. Buckland, on the *Merlangus carbonarius*, or Saith, it has occurred to me that some additional information as to the habits and uses, and more especially with respect to the commercial value of that fish, might be interesting.

"The Saith occurs in great abundance among the Orkney Islands. The fry, called Sillocks, are first observed in May or June, and are very small. In July and August they are about four or five inches long, and are caught in great numbers with flies (made with a bit of white feather tied to the hook), by means of boats, and often from the rocks on the shore. They are much esteemed as food, and more especially for the oil prepared from the livers. Towards winter they generally

set in to the Shetland bays in immense and closely congregated shoals, from which they are swept ashore by nets in enormous quantities, and are often bought by the farmer for the dunghill. At this season they fall off in quality as an article of food, but are still eagerly purchased by the country people on account of the oil, which suits better for their cottage lamps than any other kind. Next year, when nine or ten inches long, they are called Cooths, or Cuths, and are caught with the fly in the months of May, June, July, and August. In June and July they are in perfection for eating, and are cooked without taking out the entrails, after being rolled in salt and flour, or oatmeal, and done on the gridiron; but unless used within an hour or two after being caught, the fine flavor and curdy quality of the fish quickly disappear. If used next day they are somewhat coarse eating. It is a singular circumstance that they will not take the fly except an hour before or an hour after sunset and sunrise. In the third summer they become larger, and are called Cuttims, or Cuddons, in which state they betake themselves to deeper water, and are comparatively seldom caught. After this, when full grown, they are known by the name of Saith, and become an important object of fishery. The fishing commences in May, and continues till September. In July and August they are in their best state, and are sought after with great assiduity. They chiefly occur in very rapid tideways, where there is much broken water, and the fishing is not unattended with danger, several fatal accidents having occurred within my recollection by the boats having been swept by the current into the breakers. The fish average from fifteen to twenty pounds, but many specimens are met with weighing much more. When cleaned and thoroughly dried on the rocks, about seventeen will weigh one hundredweight, and yield three gallons of oil, which is equivalent to 340 fish and sixty gallons of oil to the ton. The dried article sells at market for about £12 per ton, when Codfish fetch £20 per ton, but the extra quantity of oil in the former far more than compensates for the difference in price, and consequently when a shoal of Saith sets in, the fishermen invariably desert the cod-fishing in favor of the other. Dried Saith are perfectly well known in the market, and are tolerably good eating, though inferior to Cod. The oil is chiefly used by tanners, and is in good demand. In the fresh state they are extremely good eating, firm and curdy, if cooked within an hour or two after being caught, but if kept some time they lose their flavor and become coarse. The inhabitants of Fairisle, which lies half way between the Orkney and Shetland groups of islands, pay their rent exclusively by saith-fishing."

Pollock are more highly prized in New Brunswick than anywhere else on the Western Atlantic coast, and the pollock fishery was in 1850 pronounced by Perley the most valuable and extensive of the deep-sea fisheries of the Bay of Fundy.[1] It is stated by this authority that directly after the spawning season the fish is lank and almost worthless, but that it becomes in good condition again in August and improves as the season advances.

The liver of the Pollock yields a great quantity of oil, proportionally much more than that of the Cod. It is probable that most of the cod-liver oil in the market is more or less adulterated with pollock-liver oil. No one has yet demonstrated that its medicinal properties are inferior. The eggs of the Pollock are very large, and great quantities of them have been in past years salted and exported to France.

THE ALASKA POLLACK, *Pollachius chalcogrammus* (Pallas) J. & G.[2]—The Alaska Pollock is thus described by Professor Jordan: "This species is known as Pollack to those who have seen

[1] 1877. NEW METHOD OF CAPTURING POLLOCK.—For some days past the schooner "Matchless," of Barrington, has been fishing for Pollock with a purse-seine in the vicinity of Cape Sable, and doing very well at the business, which is a kind of experiment, as the purse-seine, we believe, has been used hitherto in taking only mackerel, herring, and such small fish. On Monday of last week the crew of the "Matchless" caught at one haul about 130 quintals of Pollock, an immense catch, which took the men over twenty-fours hours to dress and salt.—*Cape Ann Advertiser.* August 17, 1877.

[2] *Gadus chalcogrammus* Pallas. Zoögr. Ross. Asiat., iii, 198. *Gadus periscopus*, Cope. Proc. Am. Philos. Soc., 1870.

the Atlantic species. It is possibly identical with the 'Beshow' of the Makah Indians, the 'Coal-fish' of the English settlers northward, a deep-water fish noted for its rich, fat flesh. It reaches a length of about two feet. It ranges from Monterey to Behring's Straits. It is taken with hook and line in deep water, and is never plentiful south of Cape Flattery. It feeds upon anchovies and the like. Nothing is known of its breeding habits, enemies, or diseases, and, unless it be the 'Beshow' above noticed, it is not sufficiently abundant to attract any notice as an article of food."

69. THE CUSK—BROSMIUS BROSME.

The Cusk, *Brosmius brosme*, is a deep-water species, inhabiting rocky ledges in the North Atlantic. It has not been observed south of Cape Cod, but ranges northward to the banks of Newfoundland and of Greenland. It occurs in Iceland and Spitzbergen and along the entire length of the Scandinavian Peninsula, but is not known on the coast of Germany, while Faber states that it just touches the most northern part of Denmark at the Scaw in Jutland, and that it is occasionally taken in the Frith of Forth and brought to the Edinburgh market. It is also plentiful about the Faroe Islands. Its range in the Western Atlantic is from latitude 42° to latitude 65°, or beyond; in the Northeastern Atlantic to latitude 80°, and south to latitude 55°.

The Massachusetts fishermen tell me that these fish are usually found in considerable abundance on newly-discovered ledges, and that great numbers may be taken for a year or two, but that they are soon all caught. Sometimes, after a lapse of years, they may be found again abundant on a recently-deserted ground. From these facts it has been reasoned that the Cusk is very local in its habits and rarely changes from one locality to another.

On the "Broken-ground Ledge" Cusk are said to be abundant at any season, and also on "New Ledge," and Captain Atwood says that they inhabit deep water in rocky localities, not hard, smooth, rocky bottoms, but large, angular rocks. About Cape Cod they are quite rare; he has seen a few to the eastward of and near Cape Cod, but they are more commonly found farther north; at a rocky spot near the eastern portion of the Middle Bank, between Cape Cod and Cape Ann, large numbers had been taken prior to 1866, and in that year 400 quintals, or probably 60,000 pounds of Cusk, had that year been taken by one Provincetown firm. Off Wells Bay, in Maine, about Cape Porpoise, and on Cashe's Ledge, he had also observed them in large quantities.

The food of the Cusk doubtless consist chiefly of mollusks and small crustaceans.

Concerning its spawning habits nothing is known, except that, according to Faber, it spawns in April and May on the coast of West and South Ireland.

The Cusk is considered a very excellent fish, especially for boiling, but there is a very limited demand for it, and most of those which are taken are salted. On account of their low prices, fishermen shun them, and they are hardly in better favor than dogfish. In the spring of 1878 they were worth in Gloucester from twenty to fifty cents per hundred, and in August of the same year about one dollar per hundred. One of their peculiar habits, eel-like, renders their capture difficult, and frequently causes the destruction of the fishing-tackle; it is said that after they have taken the hook they curl their tails round the angles of the rock and cling to them with such strength that it is impossible to dislodge them. Fishermen say that when they are brought to the surface the skin rises from the body in great blisters. This they regard as a favorable sign, as showing that the fish are "thrifty," or healthy. The name "Tusk," used for this fish in Newfoundland, is now never used in the United States, although it seems to have been in use a century ago, a well-known fishing ground in the Gulf of Maine being known as the "Tusk Rock."

70. THE HAKES—PHYCIS CHUSS, ETC.

DISTRIBUTION.—We have five species of the genus Phycis. One, *P. Chesteri*, recently discovered by the Fish Commission, occurs off the coast from Cape Ann to Cape Hatteras, at a depth of from seventy-five to three hundred fathoms. It has been collected in great numbers with the deep-sea trawl-nets used by the Fish Commission and the Coast Survey, and appears to be extremely abundant. It is, at present, of no economic importance. It may be distinguished by its exceedingly long fin-filaments.

Another species, the King Hake, *P. regius*, occurs in deep water with the preceding, and has also been found near the shore in the vicinity of Cape Hatteras, in Chesapeake Bay, and at the eastern end of Long Island. A specimen was obtained many years ago at Halifax, Nova Scotia. In the Chesapeake, according to Major Ferguson, it is very abundant.

This fish attains the length of twelve to fifteen inches. Concerning its habits little is known, except that it has the power of communicating strong electric shocks. It may be distinguished by the low first dorsal fin, unprovided with a filament and black at its tip, and by the peculiar row of white spots along the lateral line. *P. Earllii* occurs only on the coast of South Carolina.

The two species which have a commercial value are *P. chuss* and *P. tenuis*. These species are very similar in appearance, and it is with difficulty that they can be distinguished from each other by the trained eye of the zoologist. The most tangible distinction may be found in the number of scales, which are much smaller in *P. tenuis*, there being from one hundred and thirty-five to one hundred and forty oblique rows between the bronchial opening and the root of the caudal fin, while there are about twelve rows between the lateral line and the region of the first dorsal. In *P. chuss* there are only one hundred rows in the lateral line and nine rows above the lateral line; in the former the ventral does not ordinarily reach quite to the vent, in the latter it extends beyond the vent. This character, however, could not always be relied upon.

Our Hakes are all quite different from the Forked Beard, *P. blennioides*, of Great Britain, sometimes called the Hake's Dame, which is a member of the same genus.[1] Owing to their great similarity, *Phycis chuss* and *P. tenuis* are usually known indifferently by the name "Hake"; the former, however, is sometimes called the Old English Hake, and the other, *Phycis tenuis*, the Squirrel Hake or White Hake. In the Gulf of Saint Lawrence and the Bay of Chaleur, and also south of Cape Cod, they are invariably called Ling. There has been much confusion both in the names and descriptions applied to them by fishermen and ichthyologists. Their geographical range appears to be essentially the same. The young of one or both species are frequently taken swimming at the surface, on the southern coast of New England, in midsummer, and numerous individuals have been found off Block Island and Watch Hill, seeking shelter between the valves of a large species of scallop, *Pecten tenuicostatus*; the majority appear to belong to the species of *P. chuss*. About sixty were obtained from a single trawl-full of Pectens taken off Watch Hill, September, 1874, where they were found in one out of every three or four shells taken. Their companions in the interior of the shells were a species of *Pinnotheres*, related to the oyster-crab, and a species of lump-sucker, *Liparis lineatus*.

One or both species are frequently taken by the cod-fishermen, on the shoals south of Cape Cod, but they are there considered to be of but little value. They are more or less abundant in Massachusetts Bay, in the Bay of Fundy, and in the Gulf of Saint Lawrence. Large specimens of one or both species have been taken at a depth of three hundred fathoms as far south as Virginia.

[1] The Hake of Europe is a different fish, more closely related to the Silver Hake or Whiting of the New England coast, *Merluccius bilinearis*.

HABITS.—Captain Atwood gives this account of the Hake in Cape Cod Bay: "It is a ground fish, found close to the bottom, and rarely comes to the surface. They are much more inclined to take the hook by night than by day; are found on muddy bottoms, during the whole summer and autumn, along the coast of Maine and Massachusetts. They yield a large quantity of oil, which is used for the same purpose as that of the Pollock and Cod. The autumn finds them in the best condition, and, if prepared with care, they are a tolerably good table fish." Captain Atwood has known them to grow to the size of forty pounds, but the average in summer is only five to ten pounds.

Perley remarks that they are taken largely on muddy bottoms, both in the Bay of Fundy and in the Gulf of Saint Lawrence, chiefly during the night, at which time they feed on the smaller crustacea; their stomachs are then generally found to be filled. Hake are frequently taken, in the Gulf especially, measuring three feet in length.

The Hakes appear to be bottom-loving fishes, and rarely change locality. They feed on crustaceans, and occasionally indulge in a fish diet. One taken at Gloucester, in July, 1878, had a menhaden in its stomach.

It is believed that they spawn throughout the summer, for the young fish are found during all the summer months, while specimens taken at the depth of thirty-seven fathoms, August 18, 1878, off Ipswich, at a temperature of 41° F., contained well-developed ova, and were apparently ready to spawn.

USES.—An extensive fishery is carried on from Cape Ann for these fish in winter, and there are sometimes as many as fifty vessels engaged. It was estimated in 1878 that the total quantity landed at Gloucester was not far from 5,000,000 pounds. The fishing is carried on almost entirely at night with the use of trawls, which are about the size of those used in the capture of Haddock.

Hake are salted and dried in the same manner as Codfish, and are often sold under the name of Codfish. Before the introduction of boneless fish it was sometimes difficult to sell them on account of the difference in appearance, but at the present time great quantities of Hake are put up in boxes under the trade name of "boneless fish," the qualifying word "Cod" being usually omitted from the brands and labels. Hake are rarely eaten fresh.

The air-bladder, or sound, of the Hake is of great commercial value, being used extensively in the manufacture of isinglass; great quantities of sounds are sent from the British Provinces to the United States annually, sounds from the Gulf of Saint Lawrence being considered much better than those from farther south. In 1880 New England produced 255,698 pounds of dried sounds, worth $178,808. Massachusetts had eight isinglass and glue factories, employing one hundred and eighty-two men and a capital of $315,000, and producing $450,000 worth of ribbon isinglass and glue in 1879. These sounds were for the most part derived from the Hake.

Capt. Epes W. Merchant gave me the following account of hake-fishing at Gloucester in 1818: "Hake used to come in September, October, and the first half of November, and then we would get ready to go haking. Father would say, 'Go down, get your pork, and put on your squid-jig.' We were always sure of bait; the boy would catch enough bait for three men; the squid were in great schools. We used to lay out two nights and get fifteen or twenty quintals of Hake. These were worth fifteen shillings per quintal, and we sold them in Boston for the West Indies trade."

71. THE BURBOT—LOTA MACULOSA.

BY TARLETON H. BEAN.

NAME.—The first name applied to the American Burbot was *Gadus lota*. This was used by Pennant. Walbaum established the name *Gadus lacustris* for the *Mathemeg*, or Land Cod of Pen-

nant. This fish has, however, proved to be a catfish, and the name *lacustris* is untenable for the Burbot. In 1817, Le Sueur described a Burbot from Lake Erie under the name of *Gadus maculosus*, and another species from Northampton, Connecticut, as *Gadus compressus*. The name *maculosus* is the oldest available specific name for the American species. In 1818 Mitchill described a *Gadus lacustris* in the "American Monthly Magazine," evidently not knowing that the same name had been previously applied by Walbaum. In 1819 Le Sueur redescribed *Gadus compressus* under the name *Molva Huntia*. In 1842 De Kay described *Lota inornata* from the State cabinet at Albany. In 1844 D. H. Storer set up the Winnipiseogee Lake Burbot as *Lota brosmiana*. From this it will appear that six specific names have been applied to the American Burbot, and that the form from Hudson's Bay was considered identical with the European species. All of these names following *Gadus maculosus* are considered synonyms of *maculosus*. The name *compressa* was retained longer than any of the others, but it is now known that the compressed form is simply an individual variation.

Günther, in his "Catalogue of Fishes in the British Museum," volume iv, 1862, places all the names applied to the American Burbot in the synonymy of *Lota vulgaris*, believing that we have only one species, and that identical with the European. Even if his view be correct, he should use the name *Lota maculosa*, which, dating from 1817, has priority over *vulgaris*. The combination *Lota vulgaris* was not employed, as far as I know, by any author until Jenyns used it in a Manual of British Vertebrate Animals in 1835. It is not, however, established that the European and American Burbot represent the same species. The number of vertebræ seems to be smaller in the European. Günther gives it as twenty-one abdominal and thirty-eight caudal vertebræ. In two skeletons examined by myself the abdominal vertebræ were twenty-two to twenty-three, and the caudal thirty-eight to thirty-nine. There seems to be no other important difference. For the present it may be best to consider the European Burbot as varietally distinct from the American, and we should call it *Lota maculosa*, variety *vulgaris*.

POPULAR NAMES.—In the Hudson's Bay region, according to Pennant, the Burbot is known as "Marthy"; according to Richardson, as "Methy." In Alaska, according to Dall and Turner, it is known as "Losh"; in Canada, as "la Loche." In Vermont it is called the "Eel-pout" (Thompson); by which name also it is known in Mohawk River, New York, according to Loomis; in Massachusetts (Storer); in Connecticut (Wood), and in Bighorn River, Montana (Brackett). It is known as the "Dogfish" in Lake Erie, according to Le Sueur. Commander L. A. Beardslee says it is called "Chub-eel," also, in Mohawk River, New York. It is known as the "Ling" in Lake Ontario (Professor Baird), lakes of Western New York (Baird and Blackford), and New York market (Blackford). It is the "Lawyer" of Lake Michigan, according to Earll; "Lake-cusk" in Lake Winnipiseogee (Davis); "Fresh-water Cod" (Baird). It is called "Burbot" in New York (De Kay), and in the Bighorn River, Montana (Brackett). Professor Jordan gives the names "Aleby-trout" and "Mother of Eels" as in use in the Upper Great Lake region.

The above list is incomplete, both as to names and geographical range. The name "Burbot" is the one which should come into general use. The first four will hardly be adopted by English-speaking people. "Chub-eel" is a mere off-hand name given to the species by a fisherman who supposed it to be a hybrid between an eel and a catfish; this name is known to very few persons. The remaining names, except "Burbot," are preoccupied and well established for marine species, as follows: "Eel-pout," *Zoarces anguillaris*; "Ling," *Molva vulgaris*; "Lawyer," *Lutjanus cœsis*; "Cusk," *Brosmius brosme*; "Cod," *Gadus morrhua*; "Dogfish," *Mustelus canis*. The European variety, *Lota maculosa*, variety *vulgaris*, is called "Burbot," a name which has never been applied to any other species than the one under consideration, so far as I can learn. This

name, therefore, should be retained. In Norfolk, England, "Cony-fish" is a name given to the European Burbot, from its habit of skulking in rat-holes and corners under the banks.

SIZE.—We are told by J. R. Forster, in Philosophical Transactions, lxiii, 1773, p. 149, that the weight of the Burbot in the Hudson's Bay region is from one to eight pounds. According to Pennant, who derives his information from Forster, the Burbot of the Hudson's Bay region reaches a weight of eight pounds. In Alaska, Mr. Dall says that they grow to a very large size, reaching a length of five feet, and weighing as much as sixty pounds. In the Bighorn and Little Bighorn Rivers, Montana, the species reaches an average weight of less than a pound, and does not exceed eighteen inches in length. Mr. W. Ainsworth, of Cape Vincent, New York, says that the Burbot in the waters of Lake Ontario and Saint Lawrence River average two and a half pounds in weight, occasionally reaching four pounds. The United States National Museum has received from Mr. E. G. Blackford, of New York, numerous individuals from the Great Lake region, averaging certainly not less than five pounds in weight. In the United States National Museum collection the Burbot from the lakes are, as a rule, larger and plumper than those from rivers. The exceptions are one from Fort Pierre, Nebraska, and two from the Yukon River. These are longer but more slender than the lake Burbot. It seems highly probable that river Burbot may generally be recognized by their slender bodies and small size, which characters we may attribute to the small amount of food obtainable in the rivers, as compared with the supplies found in lakes. The Burbot of the Connecticut River, which furnished the type of *Lota compressa*, is short, but really less compressed than some from England, Southern Europe, and from our own lakes. Le Sueur's type of compressed Burbot may have been the starved or emaciated form known to fishermen as "Racer," and it may have been the ordinary little Burbot of the Connecticut already referred to.

RELATION TO THE EUROPEAN BURBOT.—The American Burbot cannot be distinguished from its European ally by external characters; in both, the color, the position of the fins, the number of the fin-rays, the structure and arrangement of the teeth, the situation and size of the eyes, and the relative proportions being substantially alike. There is less difference between the average American and European types of Burbot than there is between extremes of the former. At one time I thought that the number of pyloric cœca, or the length of the intestines, might be available in classification, but the amount of individual variation is so great in this respect that no division can be based thereon. The pyloric cœca in the European specimens which I have studied ranged in number from 20 to 77; in America from 36 to 138. There is only one example having the latter number, and that came from the Yukon River. Another individual from the same stream had 102 cœca, and in all probability a large series would still further reduce the gap. This variation in the number of cœca is paralleled in other species, notably in the Cod and the Salmon, *Salmo salar*. In the former I have counted 140, 160, 256, 271, 289, and 340 in six individuals. In the Salmon Mr. J. K. Thacher records a variation between 44 and 70.[1]

Even in the Craig flounder, *Glyptocephalus cynoglossus*, which has few cœca, I have counted 9 in one adult and 11 in another. The basis of distinction between the European and American forms of Burbot is solely the smaller number of vertebræ in the former. It may be that an examination of a large series of skeletons will show that the difference is constant, and it is also possible that other good characters will be found which will entitle the European form to separate specific rank, or such examination may show a European Burbot with as many vertebræ as one of our American series; in which event it would seem proper to unite the two under the name of *Lota maculosa*.

[1] Report of United States Fish Commission, part 2, 1874, p. 371.

DISTRIBUTION.—The United States National Museum has specimens of the Burbot from a tributary of Hudson's Bay, Mackenzie's River, Yukon River and Kodiak (Alaska), Winnipiseogee Lake, the Connecticut River and Scantic River, Connecticut; Seneca Falls and Madrid, New York; the Great Lakes, Winnebago Lake and Oshkosh, Wisconsin; Kansas City, Missouri; Fort Pierre, Nebraska; *the Bighorn and Little Bighorn Rivers in Montana, and Great Slave Lake.* The species occurs in the Yellowstone River, the Missouri River, in tributaries of the Ohio, in the Mohawk River, and has once been obtained in the Susquehanna River, according to Professor Cope in the report of the Pennsylvania Fish Commission, 1881.

ABUNDANCE.—The Burbot is most abundant in lakes, to wit: The Great Lakes, lakes of New *York, Winnipiseogee Lake, and lakes of Maine and New Brunswick. In general terms, including* under the name "Burbot" both the American and European forms, the species may be said to inhabit the fresh waters of the northern regions both of Europe and America, being particularly abundant in the Great Lakes and in all ponds, lakes, and large streams, thence northward to the Arctic Circle. According to Dall it is exceedingly abundant in the rivers and lakes of Alaska. *The Burbot is not known to enter brackish water at the mouths of rivers. According to* Mr. W. Ainsworth, Burbot are found principally in deep water and on mud, except during the spawning season, which occurs in March, when they run on rock or hard bottom. This refers to the Lake Ontario region. Col. A. G. Brackett, U. S. A., states that the fish seem to be quite common in the Bighorn River, Montana. In the northern rivers, as a rule, the species is very abundant, though within the limits of the United States, so far as we know, the species is less common in rivers. Mr. Charles Lanman writes that it is abundant in Lake Timisconti, and also in the Eagle and Saint Francis Lakes.

REPRODUCTION.—The spawning season of *the* Burbot *is* late winter or *early spring. It is* probable that the eggs, which are small and numerous, are deposited in deep water. Mr. Dall says that the eggs of the Burbot are of a creamy-yellow color in Alaskan specimens. The same writer states that the fish are full of spawn from November to January. He also says that a single Burbot (Losh) contains millions of eggs.

According to Pennant, the Burbot spawns early in February, and "is unhappily most prolific. Mr. Hutchins counted in a single fish 671,248 ovaria." In the Great Lake region it is considered probable that the Burbot spawns in deep water. Specimens forwarded from that region by Mr. E. G. Blackford, in the month of November, 1877, were distended with ripe eggs.

According to Mr. Dall, the males are usually much smaller than the females, averaging only *eighteen or twenty inches in length, while the female attains a length of four or five feet.* He states also that the male has a smaller liver and one pyriform gall-bladder on the left side. Some specimens, however, present the physiological curiosity of having two, or even three, distinct gall-bladders opening into the same duct, and uniform in size and shape. Mr. Dall has, however, never seen a double gall bladder in a female Burbot. The only marked feature in reference to these fish *at the spawning season is the greatly increased abundance. The young of this species are not* described in any American work, so far as I know. Richardson found small Burbots in the stomach of the Lake Trout, *Salvelinus namaycush.* He states in "Fauna Boreali Americana," p. 180, that "in the month of March, in latitude 64°, we saw that capacious receptacle [stomach of *Salvelinus namaycush*] crammed with the young of the *Lota maculosa.*"

The development of the European variety is partially illustrated by text and figures in a paper by Carl J. Sundevall on "The Development of Fishes," published in the "*Proceedings of the* Swedish Academy," 1862. The text is here in part translated:

"The spawning season of the Burbot commences in January or February. The eggs are laid

separate and loose upon the river or lake bottom. They are very small and numerous. According to the calculation of Baron C. G. Cederström, a medium-sized female contained 160,000 (by estimate, 159,776) eggs. This result nearly coincides with that of a more recent estimate, viz, that the average female contains 178,000 eggs. (Skand. Fiskar. vid., p. 41.) Some eggs are clear, some yellow, all nearly colorless, and both kinds are capable of development. In some cases the eggs commence to hatch in three weeks; generally, however, an additional week is required. At the end of the first day after the eggs have been deposited cleavage of the yolk commences. The eyes appear in fifteen or sixteen days, and in about two days more small star-like spots may be observed on the surface of the embryo. At that period, also, the beating of the heart can be plainly discerned, and I have alternately counted fifteen, thirty, and fifty pulsations in successive minutes. The evolutions of the embryo are now more distinctly seen, and it will be noticed that the anterior end of the embryo is the heavier. In many cases the eggs appear to have been prematurely hatched, and assume the shape of a ring. These move but seldom, and always in a circle. A great many die early; others are developed. The fish with straight tails are very lively, moving with a tremor of the body, usually toward the surface of the water, whence they passively fall to the bottom. When fully developed, the operation of swimming is accomplished by a quick movement of the pectorals."

MODE OF CAPTURE.—The Burbot is taken on hooks, chiefly at night. It is also captured largely in pounds and gill-nets. In Lake Winnipiseogee it is caught with the hook through holes in the ice. At Fort Custer, Montana, it takes the hook freely. In the Yukon River it is captured in fish-traps.

FOOD AND FEEDING HABITS.—The Burbot is carnivorous and voracious, having a craving and wonderfully distensible stomach, which makes the fish an efficient dredge in securing bottom fishes. Through its medium was obtained the rare sculpin-like fish *Triglopsis Thomsoni*. The Burbot feeds upon various small fishes and crustacea, frequenting the bottom, and devouring more particularly fishes with habits like its own.

Forster gives the following notes in the "Philosophical Transactions,"[1] which were furnished him by Mr. Andrew Graham: "[The Marthy is] extremely voracious, eating fish, the pike, and the tickomeg (*Salmo*), and other fish, carrion, putrefying deer, and even stones. Mr. Graham took a stone weighing a pound from the stomach of one. . . . It does not masticate its food."

Pennant says that the Marthy "is so voracious as to feed even on the tyrant pike; will devour dead deer or any carrion, and even swallow stones to fill its stomach."

The Burbot seems to feed principally at night. Pennant states that it is caught with hooks after nine o'clock at night. Charles Lanman states that "in the Saint John River, New Brunswick, some hundreds are taken annually by night-lines, dropped through the ice at the beginning of winter. Many are thus taken near Fredericton, but the best fishing ground is on the sand-bars, a little above the mouth of the Oromocto River, where this fish resorts previous to spawning, which operation takes place in February or March. This fish is not unlike the eel in many of its habits, concealing its food under stones, waiting and watching for its prey. It feeds principally at night, and is, therefore, generally taken by night-lines."

The specimens obtained by the National Museum from the Great Lakes always contained in abundance the common species associated with itself in that region, such as *Perca americana*, a species of *Lepomis*, &c.

According to Mr. Dall, the Burbot in the rivers of Alaska feed upon whitefish, lampreys, and other species.

[1] Vol. lxiii.

ECONOMIC VALUE.—There is a great difference of opinion as to the edible qualities of the Burbot. In the region of the Great Lakes it is usually pronounced worthless, but some few consider the liver a delicacy; it is held in low esteem as a food-fish, and rarely appears in the markets. It was formerly thrown away, according to Mr. Milner, although it is a very good edible fish, and some who know its qualities cook the livers of the larger specimens, considering them very choice. Mr. Ainsworth, of Cape Vincent, New York, regards the Burbot as a great annoyance to gill net fishermen. He states that they are a soft fish and unmarketable. I have been told that the Burbot caught through holes in the ice in Winnipiseogee Lake are highly esteemed. In the fur countries, according to old writers, the roe is an article of food. The liver is eaten in the Yukon River region, and the flesh is by some regarded as equal to that of whitefish. At Fort Custer, Montana, Col. A. G. Brackett says, "The soldiers eat all they can get of them." Indians generally are fond of them. No doubt the quality of the flesh depends largely upon the habitat, those found in cold, clear, rapid streams being probably the best.

According to Professor Jordan, there is a popular prejudice against the looks of this fish, and its flesh is less rich than that of most of the lake fish. From the manuscript of Charles Lanman, referring to the species in New Brunswick, I quote the following: "The flesh of the fresh-water Cusk is white, firm, and of good flavor. The liver and roe are considered delicacies; when well bruised and mixed with a little flour, the roe can be baked into very good biscuits, which are used in the fur countries as tea-bread."

Forster states that the roe and liver, when fresh, are considered delicacies, but that they turn rancid in a few days. On the coast of Hudson's Bay the fish is considered dry and insipid.

The Burbot, therefore, does not appear to be a very important fish, commercially speaking, although when taken in cold streams, where it occurs in abundance, it is freely eaten. In Siberia, according to Mr. Dall, the skins of the European variety are used as a substitute for glass in windows.

INFORMATION DESIRED CONCERNING THE BURBOT.—Information is greatly desired on all of the points already mentioned concerning the Burbot, and especially on the following particulars:

1. Its occurrence in rivers and lakes *anywhere*. Kansas City, Missouri, is the most southern locality represented in the collections of the United States National Museum.
2. The temperature and depth of the water in which it is captured.
3. Its capture in salt water.
4. Its time and mode of spawning in different waters.
5. The appearance of the young.
6. Its food. Bottom fishes are frequently found in the stomach.
7. Whether it is eaten.
8. How caught.

The Commissioner of Fisheries is desirous of obtaining specimens in alcohol or in the fresh state from any river or lake, except the Great Lakes and lakes of Western New York.

72. THE SILVER HAKE AND THE MERLUCCIO.

THE SILVER HAKE, OR NEW ENGLAND WHITING. MERLUCIUS BILINEARIS.

DISTRIBUTION.—It is the opinion of certain writers, among whom Dr. Günther is leader, that the Hake of Europe, *Merlucius merlus* (or *M. vulgaris* of recent authors), is identical with the species of *Merlucius* occurring in the Western Atlantic. This is, however, a mistake; the American species may easily be distinguished from that of Europe by the greater number of rays

in the first dorsal (10 to 11 in *M. merlus*, 12 to 13 in *M. bilinearis*), and by the larger size of the scales (the number in the lateral line being about 150 in *M. merlus*, 100 to 110 in *M. bilinearis*).

The general appearance of the two species is very similar, and it requires careful study to separate them. It is probable that at no very remote period they diverged from a common stock. The distribution of the two species upon the opposite sides of the Atlantic coincides very closely with that of other Gadoid fishes, which are specifically identical in Europe and America. The Hake of Europe is found along the coast from Trondhjem Fjord, latitude 65°, south to 36°, being very abundant in the Mediterranean; also found on the coast of Portugal and in Western France. In the English Channel, however, and in the waters of Holland and Germany, it is considered very unusual. On our coast it ranges from New York to the Gulf of Saint Lawrence, where it is common—especially in the Bay of Chaleur—but it has rarely been observed as far north as the Straits of Belle Isle. Dr. Packard was told by fishermen that during a period of forty summers spent on the coast of Labrador they had taken but one specimen of this fish. This fish has been found at great depths as far south as latitude 36° and 37°.

The name Silver Hake, by which this fish is known in the Bay of Fundy, is much more appropriate than that of Whiting, though the latter is more frequently heard in New England; its similarity to the European Hake is very great; while the name Whiting, which is in Europe applied to a species (*Merlangus vulgaris*), somewhat resembling the Pollock, has been appropriated in this country for a fish on the southern coast and belonging to the drum family.

MIGRATIONS AND MOVEMENTS.—The Silver Hake commonly inhabits the middle depths of ocean, or the outer edge of the continental slope, and comes to the surface to feed. Like the Pollock, it is a fish of prey; its teeth are sharp, its mouth large and powerful, and its form lithe, muscular, and adapted to rapid locomotion. It comes to the surface to prey upon the schools of herring and other small fish, and is frequently caught in the mackerel and bluefish nets. Its appearance in our waters is irregular, and when seen it is usually in considerable numbers. Storer, writing in or before 1867, remarked: "When my report was published in 1839 I stated that the Whiting was taken—not, however, in large quantities—in our bay in the summer upon the cod-fishery grounds; since that period this species has increased very perceptibly in our waters; it is frequently caught in considerable numbers with the hook upon Crab Ledge, a few miles from Boston light-house, and has become at Provincetown a serious inconvenience to the fishermen. Captain Atwood informs me that when the fishermen at the latter place commence the mackerel fishery with nets, which usually takes place about the 20th of May, the Whiting are scarce and few are caught. By the 1st of June they become more plenty, and from the middle of June to the last of the fishery, which closes about the 20th of July, they are exceedingly numerous in parts of the bay in all depths of water. In such quantities are they taken in nets that frequently eight or ten hours are required for a man to clear the nets of them. At this season of the year so many of them are thrown from the boats upon the shore that the board of health is sometimes called upon to interfere and to compel the fishermen to bury them from the fear of sickness being produced by their decomposition. By visiting this point, the easterly extremity of Cape Cod, in June, 1847, I saw quite a number of this species strewed along the shore, where they had been left by the tide while in pursuit of sand-eels and other small fishes. Since that period, the bluefish having been more common, this species does not exist in as great abundance."

It is difficult in this case, as in many other similar ones, to decide exactly what dates to assign to the observations of Dr. Storer—his "History of the Fishes of Massachusetts," in its last edition, having been published at various times from 1863 to 1867—as in some instances he contented himself with quoting the exact words of his report printed in 1839. It would seem,

however, that the statements attributed to Captain Atwood should be dated prior to 1850. The Cape Cod naturalist, in his address before the senate committee of the Rhode Island legislature in 1872, stated that in Provincetown Harbor, from a very early period until the "horse-mackerel" (bluefish) made its appearance, the fish called Whiting was immensely abundant; but since the horse-mackerel had appeared this fish was driven out, and at the time of speaking a specimen was hardly ever seen. Perley, writing in 1850 and 1852, stated that at Grand Manan these fish were often taken in herring nets, in which they become entangled while pursuing their prey, and that he observed the fishermen throwing away these fish by thousands while clearing their nets.

HABITS.—They average one foot in length. They are of roving habits, following the shoals of herring, which they devour in great quantities. Until 1880 little was known concerning the breeding habits of the Silver Hake, but, in exploring the bottom, at a depth of from one hundred and fifty to three hundred fathoms, off Newport and in the edge of the Gulf Stream, immense numbers of young fish, from half an inch to three inches in length, were found at the bottom, and with them were many adults, twelve to eighteen inches in length, apparently in the act of spawning; some of them with the ova ripe, or nearly ripe, but not yet shed; others evidently spent fish. This discovery was exceedingly interesting, since it may serve as a clew to the spawning habits of other species, like the bluefish and menhaden, which have been supposed to spawn at a distance from the shore, but have never been detected in the act. The spawning period doubtless extends over a considerable space of time; some of the eggs from which the largest of the young were hatched off Newport must have been laid as early as July. In September an adult, obtained at Halifax, Nova Scotia, had the ova well developed and nearly ready for deposition. It is not known whether the eggs of the Silver Hake float or sink. Couch states that the spawning season of the European Hake is from January to April, at which time the fish are caught near the bottom, and lose the great voracity by which they are characterized at other times, so that multitudes are caught in trawls, and a few with lines. When pilchards approach the shore the Hake follows them, continuing in incalculable numbers throughout the winter. Mr. Couch continues:

"It rarely happens that pilchards are taken in the seine without many Hakes being inclosed with them, and thus, when the net remains in the water for several days, they have an opportunity of glutting themselves to their hearts' desire, which is to such an extent as to render themselves helpless, and I have seen seventeen pilchards taken from the stomach of a Hake of ordinary size. Their digestion is quick, so that they speedily get rid of their load, and fishermen observe that when hooked the fish evacuates the contents of its stomach to facilitate its escape, so that when hundreds are taken with a line in the midst of prey, not one will have anything in its stomach. When near the surface, however, this ejection does not take place until they are dragged on board."

In Holland this fish is known as the Stokvisch, and in Germany as the Meerhecht or Little Stockfisch; the first name signifies sea-pike, this name being the equivalent of the Latin generic name.

USES.—The Hake of Europe is always considered a coarse fish, and though great quantities are annually salted and dried it is not held in very high esteem. Many of the salted fish are sent to Spain. They are said to be quite common on the northern shore of the Mediterranean, where considerable traffic is carried on with them; they are packed with aromatic plants and sent to the towns remote from the coast.

Storer remarks: "Occasionally this species is brought to market, and when perfectly fresh is a very sweet fish, boiled, broiled, or fried. It soon becomes soft and is preserved with difficulty. As it does not appear to be known abroad, and the fishermen consequently have no call for it, it is

not cured, but is considered worthless. In the months of September and October the Whiting is used somewhat for bait for the dogfish and answers a good purpose."

It is, as a rule, hardly worth while to criticise statements in a work so generally unreliable as J. V. C. Smith's "History of the Fishes of Massachusetts," published in 1843, but since he has been quoted by De Kay[1] in a misleading manner, it should here be stated that in discussing this fish this author had also in mind other fishes belonging to the genus *Phycis*, which are known by the name of Hake all along the coast.

THE MERLUCCIO OR CALIFORNIA HAKE. MERLUCIUS PRODUCTUS.

The California Hake, writes Professor Jordan, is most commonly known along the coast by its Italian name, "Merluccio", pronounced *merlo͝och*. At Soquel and elsewhere it goes by the name of Horse-mackerel, a name used on our coasts with the greatest carelessness, being applied to *Elops saurus*, *Anoplopoma fimbria*, and *Merlucius productus*, as well as to various scombroids and carangoid fishes. It reaches a length of about thirty inches and a weight of ten pounds, its average weight being five or six. It is found from the Island of Santa Cruz to Alaska, being very irregular in its appearance, some years very abundant and at other times wanting altogether. It is exceedingly voracious, feeding on all sorts of small fishes and squids. The stomach is always filled almost to bursting.

It spawns in the spring, and its arrival near the coast always precedes the deposition of the spawn. It probably then retires to deeper water.

Its value as a food-fish is very little. It is scarcely salable in the market of San Francisco. Its flesh is very soft, and it is always ragged-looking when shipped. Nothing was learned as to the quality of its flesh, but it probably differs little from *M. bilinearis*.

73. SEVERAL UNIMPORTANT FAMILIES RELATED TO THE GADIDÆ.

THE CONGROGADUS FAMILY (*Congrogadidæ*).—This family, which in some respects resembles the eels and in others the Codfishes, contains, in all, three species: one from Australia, one from the Red Sea, and the third, a small eel-like fish, of great activity, *Scytaliscus cerdalis*, which lives among the rocks on the coast of Washington Territory.

THE FIERASFER FAMILY (*Fierasferidæ*).—These are never of very large size, and are eel-like in shape. As far as is known, they live parasitically in the cavities of other marine animals, especially in the respiratory cavities of star-fish and sea-slugs. Not unfrequently they attempt to live in animals less suited to their habits, as, for instance, bivalves, and cases have been known where they have been imprisoned below the mouth of the mollusk or covered over with a layer of the pearly substance secreted by it. They are perfectly harmless to their host, and merely seek for themselves a safe habitation, feeding on the animalcules which enter with the water the cavities inhabited by them.[2] Three or four species of this family are known to occur on our Florida and Gulf coasts.

THE SAND CUSK FAMILY.—The family *Ophidiidæ* is represented on the Atlantic coast by a fish so rare as to have no common name, the *Ophidium marginatum*, which is found burrowing in the sand banks near Beaufort, North Carolina, occasionally at other places, and on the coasts of our Southern and Middle States,[3] and by several rare deep-sea forms. On the California coast is a similar

[1] New York Fish Fauna, p. 82.

[2] GÜNTHER: Study of Fishes, p. 549.

[3] "We dug two specimens out of the sand near low-water mark (Great Egg Harbor, April, 1871), where they burrowed to the depth of a foot or more. When placed upon moist sand, they burrowed into it, tail foremost, with surprising rapidity, disappearing in an instant. The species appears to be rare.—VERRILL: American Naturalist, v. 399.

species, *Ophidium Taylori*, about a foot in length. This species occurs from San Francisco to the Santa Barbara Islands. It is rare, and only brought into the market by accident.

THE RED CUSK FAMILY (*Brotulidæ*).—This family, which is composed of fishes belonging in the deeper regions of the Atlantic and Indian Oceans, is not represented on our Atlantic coast, save by certain obscure deep-sea forms. A single species is known in California, the so-called Red Cusk, *Brosmophycis marginatus*, known to the Italians of that region by the names Mustèt or Musteta. This fish reaches the length of eighteen inches. It has been noticed only in the neighborhood of San Francisco, where it occurs in waters of considerable depth. On account of its bright colors, it meets with a ready sale in the San Francisco market, but is too rare to be considered as of any great economic importance.

THE GRENADIER FAMILY (*Macruridæ*).—The Grenadiers, or, as the fishermen frequently call them, on account of the size and shape of their eyes, "Onion-fishes," inhabit the deep parts of the ocean. They are particularly abundant in the Western Atlantic. They are occasionally eaten, but are chiefly important to the fishermen on account of their habit of stealing the bait and taking possession of the hooks, which would otherwise be free for the capture of more useful fishes. The largest species, and the one best known to the fishermen, is *Macrurus rupestris*, called "Rat-tail Fish" as well as "Onion-fish". It is exceedingly abundant on all of our off-shore banks, attaining a length of three feet and a weight of four or five pounds.

A smaller species, *Macrurus Bairdii*, is found everywhere along the coast where the depth is greater than eighty or ninety fathoms. It is probably an important article of food for the larger fishes of these regions, such as the halibut. At least four species of this family occur on our coast, all of which have been brought to light by the explorations of the United States Fish Commission within the past four years.

74. THE LANT, OR SAND-EEL—AMMODYTES AMERICANUS.

HABITS.—Of all the small species of fishes occurring in the North Atlantic there is probably none more important to man than the Lant—Launce, as it is called in Europe, frequently also the Sand-eel both in Europe and America, Tobias-fish in Germany, and Smelt in Holland. The American and European species, though similar, are quite distinct forms.

Although it is never used for food in this country, it is of great economic importance, since it constitutes one of the chief articles of food for the codfish, the halibut, and other flesh-feeding species, such as the bonito, bluefish, squeteague, flounder, and mackerel, and in Europe the turbot.

The Lant is a slender species, with a rounded body, the height of which is contained from eleven to twelve times in its total length; the largest individuals grow to be about sixteen inches long, but they are usually much smaller. They swim in immense schools at the surface, and frequently imbed themselves in the sand, where they often remain above the low-water mark while the tide is out. Why they do this is not well understood, for in their habits they are wanderers, sometimes appearing in immense numbers at certain points upon the coast and disappearing as rapidly as they came. With their sharp noses and slender muscular bodies they have little difficulty in imbedding themselves in the soft sand several inches deep. I shall never forget my surprise when, many years ago, unfamiliar with the habits of this fish, which, indeed, was at that time entirely unknown to me, I was digging up shells in one of the sandy beaches in Provincetown Harbor, when suddenly, as I struck my hoe into the earth, a great section of the beach became alive with glancing forms of dozens of these agile little fishes.

"On the sands of Portobello, near Edinburgh, and at other places, people take advantage of

this well-known habit, and when it is discovered that a shoal of Sand-eels have hidden themselves in the sand they sally out, armed with spades, rakes, shovels, and forks, and dig them out. When extricated from the sand-beds the fish leap about with singular agility, and afford much sport in capturing them. Perhaps the fun in catching them has originated the saying, 'As jolly as a sand-boy.'"[1]

They are captured in a similar manner on the coast of Holland. It is Buckland's idea that they go into the sand to take refuge from fish which are pursuing them.

Captain Atwood, writing to Dr. Storer during 1847, said: "On last Friday night they ran ashore in such quantities in Provincetown Harbor that they covered the ground from one to two inches deep, and when the water covered the flats the whole bottom looked like an immense sea of silver." "When thus situated," continues Storer, "they are readily devoured by their enemies, among whom are the cuttle-fish," or squids.

Various authors have stated that they feed upon the very young fry of other fish and upon small worms.

Speaking of a closely related species, *Ammodytes tobianus*, which has not yet been found in the Western Atlantic, but which may yet very probably be discovered here, and whose habits are doubtless very similar, Oliver writes that they follow the young fry of the coalfish, or pollock, into the harbor, and are frequently caught with the same bait. They swim rapidly and dash at a shoal of fry with the voracity and swiftness of a pike, and they even feed upon the young of their own kind.

As has already been stated, they constitute a favorite bait for many other species of fish. They are very conspicuous by reason of their bright silver color, and their swift motion is easily imitated by trawling them behind the boat in rapid motion. Their form has been imitated in India rubber and metal for use in angling. In England they are a favorite bait for the bass. Couch states that they are frequently followed by mackerel, and that their presence is a sure sign of good fishing. "On a calm evening it is an interesting sight to see the surface of the water broken by the repeated plunges of the voracious fishes as they break upon the little school of Launces from beneath. Their only certain place of refuge from these pursuers is the sand."

Owing to the confusion between the two species of *Ammodytes*, European naturalists have not yet come to a definite decision as to their time of spawning, but the observations of Benecke indicate that this takes place, in the Baltic at least, in May, the fish being most abundant in those waters from July to September. No one has observed these habits on our own coast.

DISTRIBUTION.—The distribution of the Lant in the Western Atlantic appears to be limited at the south in the vicinity of Long Island Sound, although it is stated by Uhler and Lugger to occur on the coast of Maryland. Northward it is found at least as far as Sloop Harbor, Labrador. On the Scandinavian coast it has not been found north of Trondhjem Fjord, latitude 65°, though the other species is found up as far as North Cape. It enters the Baltic, occurs everywhere throughout the British Isles, is abundant in Holland and along the northern coast of France. In summer they are frequently seen in immense schools on the southern coast of Massachusetts. Captain Atwood gives the following account of their movements in Cape Cod Bay:

"Lants are common, and sometimes they are plentiful. Some winters there comes on a cold spell, and if the wind is just right they drive ashore, and you may pick up bucketfuls, while sometimes winters have passed away when I have not noticed but a few. One year, before 1847 I should think, the Lant came in in immense quantities. The whiting drove the Lant in, and they began to run ashore at high water, and ran ashore till low water, and they covered the whole ground so I should think they would be one and a half or two inches deep. There was not a place

[1] BUCKLAND: Familiar History of British Fishes, p. 193.

on the whole inside of the point the next day but was sheeted over with these Lant. On the day after the wind came on and blew heavy from the westward, and it swept the beach off as clean as you could sweep a floor. They come in winter and in summer, and are quite common on the coast, and on the Banks of Newfoundland there are immense numbers of them. I have frequently seen them in the stomachs of codfish."

The Lant is found in spring or early summer in the open sea, in the neighborhood of banks and shoals remote from land, as is also the sprat in Europe and the "brit," "eyebait," or small herring in America. Professor Sars has given a detailed description of the manner in which the vast schools of young herring to the Norwegian shore in summer not only attract the large cod and many other fish from the deep sea towards the shore, but also draw the yearling and two-year-old cod *from* the shore to meet the incoming schools.

USES.—As has already been stated, this fish is not used for food in the United States. Its importance is well understood by our fishermen who go after cod to Labrador and Newfoundland. They are said to be common in the Edinburgh market in summer, while in Southern England they are salted and dried for winter use. In Edinburgh, too, the other species, called the Horness, or Horned Eel, is brought to the market in August and sold by the thousand. Parnell states that this species spawns in September, and that their flesh is wholesome and palatable.

Captain Atwood has also recorded some curious observations concerning the manner in which these fish, with their sharp snouts, penetrate through the stomach of the codfish which has eaten them, into the walls of the body, and there become encysted in the flesh, forming hard, black masses which are very inconvenient to the fishermen, because they dull their knives which they use in dressing the fish before drying them.

K.—WOLF-FISHES, SCULPINS, AND WRASSES.

75. THE LYCODES FAMILY—LYCODIDÆ.

This family is represented on our Atlantic coast by eight or ten species, and on the Pacific coast by three others. They are large-headed, elongate fishes, with eel-like bodies, covered with a lax, thick, slimy skin, and for the most part inhabit very deep water, and are seldom seen except by the naturalist, and by the fisherman, who counts them among the refuse products of his lines.

MUTTON-FISH.—The Mutton-fish, *Zoarces anguillaris*, called Congo Eel and Ling, and also Lamper Eel, especially by the Maine fishermen, is often seen near the shore north of Cape Cod, and in winter especially is frequently taken with hook and line from the wharves. This species occasionally attains the length of three feet and the weight of six or seven pounds.

The Mutton-fish feeds upon crustaceans and mollusks, and spawns in July and August in the deep waters of Massachusetts Bay, its eggs being as large as buckshot and not very numerous. The young fish are frequently taken in the Fish Commission trawl-nets. This species has been recorded as far south as Fort Macon, in North Carolina, where Dr. Yarrow claims to have taken two specimens, fishing from one of the wharves; and H. R. Storer found it in Southern Labrador, at Bras d'Or, where he observed that it was frequently taken in the herring seines. In Northern Europe is an allied species, *Z. viviparus*, which brings forth its young alive, the embryos attaining a length of four or five centimeters before leaving the mother, and in the Baltic making their appearance in August or later. Malm records the capture in Southern Sweden, November 17, 1873, of a female with three hundred fully developed young, about forty millimeters long. It is not yet definitely determined whether or not our species is viviparous, but it seems somewhat improbable, although one taken in Gloucester Harbor, at a depth of eight fathoms, in a temperature of 41° F., July 30, 1878, contained eggs which seemed almost mature enough to be deposited. This is known in Germany as the Aalmutter, or Mother of Eels; in Holland, Puit Aal; in Scotland as the Bard or Maroona Eel; in England as the Guffer, Eel-pout, or Green-bone; and in Southern Sweden as the Aolkussa; the distribution of which is limited on the south by the English Channel, on the north by the North Cape and Varanger Fjord, latitude 71°. It enters the Baltic, where it is frequently taken on the Prussian coast, especially about Memel.

The Mutton-fish, like the Wolf-fish, or Sea Catfish, is one of those species which, while possessing excellent qualities as a food-fish, is not generally eaten. Mitchill speaks of having seen them in considerable numbers in the New York markets in March, 1813, and De Kay in 1842 wrote: "I have noticed this fish is most abundant in the New York markets in February and March. It is caught on the coast in company with the common cod. It feeds on various marine shells and affords a very savory food."

In Gill's paper on the "Fishes of New York Markets," written in 1856, this fish is not mentioned as one of the kinds at that time sent to New York.

Storer writes: "It feeds upon the mollusca and testacea, and the flesh of the young fish is sweet and very palatable. It is seldom met with in Boston market; occasionally, however, it is brought in by the cod-fishermen of Massachusetts Bay."

It is occasionally eaten by the Cape Ann fishermen, by whom it is known as the Mutton-fish,

the name referring to a supposed resemblance of its flesh to mutton; and I can myself testify to the delicacy of its flavor. The European species is also on the border-line between food and refuse fishes. Parnell writes: "In the Firth of Forth it exists in great plenty, hiding under sea-weed in rocky situations. They are even taken with lines in the winter months and brought to market, where they fetch a ready sale at the rate of three a penny. Some people consider the flesh as very fine and wholesome, while others, again, announce it as dry and of a disagreeable flavor. The bones of this fish when boiled assume a green appearance, from which circumstance the fish oft-times receives the name of Green-bone."[1]

Mr. Neill says: "Though not a delicate morsel, this fish is often brought to the Edinburgh market."

In Holland and Germany they are not often eaten; there is a general impression, however, that they are edible.

PACIFIC LYCODIDS.—This family is represented on the Pacific coast by *Lycodopsis pacidens* (Lockington) Jor. & Gilb., and *L. microstomus* Lockington, small fishes, scarcely a foot in length, living in rather deep water from San Francisco northward. They have no economic importance, being only brought into the market when mixed with the tomcod and "soles."

76. THE WOLF-FISHES OR SEA CATFISHES—ANARRHICHADIDÆ.

SEA CATFISHES.—The Wolf-fish family is represented on our Atlantic coast by three species—all large, voracious, and frequently taken by cod and halibut fishermen. The best known, and in fact the only species definitely ascertained to occur in the Western Atlantic until the other two were recently brought to light by the labors of the Fish Commission, is the common "Catfish" of the fishermen, *Anarrhicas lupus* Linnæus, and which is found throughout the northern parts of the Northern Atlantic, ranging upon the New England coast south to the region of the Nantucket Shoals, where it ever breeds in deep water, young specimens having been obtained by the Fish Commission at a depth of over one hundred fathoms in the summer of 1880, while in 1874 several specimens were brought to Noank, caught by the New York smacks on the Nantucket Shoals, the largest four feet or more in length. De Kay records the capture of a specimen four feet long off Block Island, and states that they are not unfrequently taken off Rock Beach in company with the common cod.

In the Eastern Atlantic it is found in the German Ocean, on the south coast of Great Britain and in the Channel, and along the shores of Holland.[2] According to Richardson it is somewhat common on the French coast. Though it does not appear to enter the Baltic, it is found on the coast of Norway and in the Cattegat. Yarrell records the capture of this fish on the coast of Yorkshire, in the Frith of Forth, and in the Orkneys. Collet records its presence everywhere along the Norwegian coast up to the North Cape and Varanger Fjord in Eastern Finmark, while it is known to occur in Iceland and Greenland and along the entire eastern coast of Northern North America. This is the best known species, and until recently all others have been confounded with it. It is readily distinguished from the others by its general color of gray slate, or light brown, marked with from nine to twelve transverse bands of darker hue. By many of the nations of Northern Europe it is called the Catfish; and this name is still in general use among our own sea-fishermen, although the fishes most generally known in North America by this name are fresh-water species of the family Siluridæ, closely related to the sheet-fish or wels of Europe. To an untrained observer there is some resemblance between these fishes and the Catfish of the

[1] There is no evidence that the bones of the American species ever become green. The name Green-bone is also applied in Europe to the silver gar-fish.

[2] SCHLEGEL: De Dieren van Nederland. Visschen, p. 68.

sea, to which resemblance they doubtless owe their common name, bestowed upon them by the early English settlers. They are also called in this country "Wolf-fish," this being the common book-name. In the Orkneys the name is "Swine-fish," professedly on account of a peculiar movement of the snout which has been observed; while in Scandinavia the name "Stone-biter" is also common. Another species, which may be called the Spotted Cat-fish, or the Wolf-fish, is occasionally obtained by our cod-fishermen on the off-shore banks, and has been taken near the shore in the Bay of Fundy. In form and general appearance it is similar to the species just described, but instead of transverse bands of brown or black it is marked with numerous circular spots and blotches; sometimes several of these are confluent, forming a large, irregular blotch. This species, *Anarrhicas minor*, Olafsen, has been observed on the coast of Norway throughout nearly its whole extent, north of latitude 58°; it occurs in Iceland, whence were received the first specimens, and on our own coast has been seen in the Bay of Fundy and on several of the banks north of Georges.

Besides these two, there is the "Blue Cat-fish", *A. latifrons*, which is much smaller, rarely exceeding three feet in length, with a very soft and flabby body, and of a uniform blue-slate or mouse color. This is a resident of the deep waters, in two to four hundred fathoms, on the outer edge of the off-shore banks, and has also been observed in the northern parts of Europe. Dr. Bean has recently described a species from Alaska somewhat resembling *Anarrhicas lupus*, but without the cross bands; the color of the alcoholic specimens is dark brown without bands or spots, and with belly of light brown or gray clouded with very dark brown. To this he has given the name *Anarrhicas lepturus*. The types were obtained at Saint Michaels.

The Wolf- or Cat-fishes are, emphatically, lovers of cold water, their range corresponding closely to that of the halibut, though perhaps not extending quite so far southward. They are almost invariably found upon the same feeding-grounds, where the Cat-fish devour the heavy-shelled crustaceans and mollusks which are too strongly protected to be eaten by other fishes. According to Fabricius it migrates from the coast to the deep sea in the autumn and returns again in the spring, being associated in these movements with the common lump-fish.

It is impossible to imagine a more voracious-looking animal than the Sea Cat fish, with its massive head and long, sinuous, muscular body, its strongly rayed fins and its vise-like jaws, armed with great pavements of teeth, those in front long, strong, pointed like those of a tiger, closely studded, re-enforced in the rear by others rounded and molar-like, adapted for crushing the objects which have been seized by the curved teeth in the front of the jaw. The character of their food has already been mentioned. Professor Verrill found in the stomach of one of these fishes over a quart of spiny sea-urchins, and it is believed that upon these and upon hermit-crabs they depend very largely for food. They are pugnacious in the extreme, and have been known to attack furiously persons wading at low tide among the rock-pools of Eastport, Maine. When one is lifted into a fishing-boat, which is a not unfrequent occurrence, it is necessary to kill it at once to prevent it from injuring the fishermen, by biting or stabbing them with its sharp spines. They are quickly killed by blows upon the head.

The only record of the spawning time of the *Anarrhicas lupus* in Europe, which I can at present find, is in Schlegel's "Fishes of the Netherlands," where it is stated that it occurs in May and June. It is probable that on our own coast the period is approximately the same, since young fish of one and two inches in length have been several times taken by the fishermen in August and September. DeKay states that they spawn in May. According to Fabricius, it spawns on the Greenland coast in May among the largest seaweeds, a short way from the shore. The largest individuals of this species are six or seven feet in length, and would probably weigh forty pounds. The specimen mentioned by Richardson, three feet long, weighed twenty pounds.

It cannot be said that they are at present of great economic importance. Storer, writing in 1867, said: "By many of our fishermen it is considered very delicate; the smallest specimens, from five to ten pounds, are quite palatable when fried or broiled, the skin having been previously removed; it is also occasionally split and salted or dried and smoked, and is said to be, when thus prepared, very good."[1]

Parnell wrote: "It is quite common in the rocky parts of the Firth of Forth, and also found on the haddock lines, and is occasionally taken in the same nets above Queen's Ferry. About June the young are about two feet in length, and are sold in the market for sixpence each. The appearance of this fish is not very prepossessing, and the natives are not aware of its quality as food; but if properly dressed and disguised by the head being cut off, it is considered equal to many of the marine fishes."[2]

Yarrell says: "According to Mr. Neill, specimens of small size, about two feet in length, are frequently brought to the Edinboro' market; and those who are able to overcome the prejudices caused by its appearance find it good food. Mr. Hoy and Mr. Low have borne their testimony to the excellence of its flesh, and Mr. Donovan states that it is delicious. It may be observed here that this is the general character of the flesh of those fishes that feed on crustaceous animals. It is eaten by the Greenlanders and Norwegians, as well as by most of the inhabitants of the northern part of Europe, the head and skin being first taken off. The skin is converted into very durable bags and pockets.[3] Malm writes: "They occur along the whole coast of Bohuslan, and are caught most frequently of all from March to May."

Frank Buckland remarks: "Notwithstanding the ugly appearance of this fish its flesh is said to be of a very good flavor. It is sometimes seen hung up in the shops of London fish-mongers, and I can, for the most part, say that it is very good; I can compare it to nothing but a nice veal chop." DeKay also bears testimony to their excellence, saying that "when smoked their flesh is very similar to that of salmon." Schlegel says they are not eaten on the coast of Holland.

On the Pacific coast there is a fish of a closely-related genus commonly known as the Eel, *Anarrichthys ocellatus*. This species is commonly known as the "Eel," or "Wolf-eel," the latter name probably having been given by some one familiar with the Atlantic Wolf-fish. The name "Azia" is given to it by the Dalmatian fishermen on Puget Sound, and that of "Morina" by the Italians at Monterey. It reaches a length of eight feet and a weight of about thirty pounds. The average length is five to six feet. It ranges from Monterey to Puget Sound, lurking among the rocks, and occasionally left by the falling tide. It is not rare about San Francisco, but becomes much more abundant northward. It feeds on crustaceans, echinoderms, and fishes. According to Mr. Lockington the broken shells of *Echinarachnius excentricus* are often found in its stomach. Nothing special is known of its breeding habits, enemies, or diseases. As a food-fish it meets always with a ready sale.

77. THE BLENNY FAMILY—BLENNIIDÆ.

The Blenny family is represented on the Atlantic coast of the United States by two species of insignificant size and absolutely without value. Upon the Pacific coast they are represented by numerous small fishes, mostly living about the rocks between tide-marks, and often exceedingly abundant. A few of them live in the kelp, and some of them swim freely in shallow water. Large individuals are occasionally brought into the markets, especially of *Xiphister mucosus*, *Cebedichthys*

[1] Fishes of Massachusetts, p. 100.
[2] Fishes of the Firth of Forth, p. 240.
[3] British Fishes, 1836, vol. 1, p. 248.

violaceus, and *Heterostichus rostratus*, often selling as "eels," at thirty cents per pound. In general these fishes are, from an economic point of view, entirely insignificant, and probably not a hundred pounds a year of them are sold on the whole coast. The *Lumpenus anguillaris* is often taken in large numbers in the seines, but a prejudice seems to exist against it and no one will eat it.

The following is a list of the Blennioid fishes: *Lumpenus anguillaris* (Pallas) Gill, from Cape Mendocino northward; abundant. *Apodichthys violaceus* (Ayres) Grd.; *Xiphister rupestris* Jor. & Gilb.; *Xiphister mucosus* (Grd.) Jor.; *Xiphister chirus* Jor. & Gilb.; *Aproplarchus atropurpureus* (Kittlitz) Gill; *Apodichthys flavidus* Grd.; *Apodichthys fucorum* Jor. & Gilb.; all these living among rocks and ranging from Monterey to Alaska; *Murænoides ornatus* Girard, from Cape Mendocino northward; *Cremnobates integripinnis* Rosa Smith; *Gibbonsia elegans* Cooper, and *Hypleurochilus gentilis* (Girard) Gill, among rocks, chiefly from Point Concepcion southward; and finally *Neoclinus satiricus* Grd., *Neoclinus Blanchardi* Girard, and *Heterostichus rostratus* Girard, living in the kelp along the shore from Monterey to Lower California.

78. THE TOAD-FISH—BATRACHUS TAU.

The Toad-fish, *Batrachus tau*, called also on the coast of New Jersey and in some parts of the Southern States "Oyster-fish," is one of the most repulsive looking fishes upon our coast, with its dark, slimy, almost shapeless body and its mud-wallowing habits. In general appearance it resembles a sculpin without prominent spines upon its head or upon its fins. Although it is armed with by no means insignificant spines, which are capable of inflicting serious cuts, when touched they show no disposition to bite, but erect their opercular spines in a very threatening manner; these are so covered by the lax skin that they can scarcely be seen.[1]

Species of this family inhabit the coasts of nearly all the tropical and temperate regions of the world. The American species was the first brought to notice, specimens having been sent about 1761 from South Carolina by Dr. Garden to Linnæus, by whom it was described under the name *Gadus tau*, the great Swedish naturalist considering it to be a kind of codfish. The name which he gave it refers to a character not discernible except in dried specimens, the bones of the upper surface of the scale forming a group of ridges which resemble in shape the Greek letter *T*.

Our species is found in shallow waters from Cape Cod south at least as far as to the mouth of the Mississippi River. In the Gulf of Mexico, however, it is found in deep water, and many large ones are taken on the snapper grounds at a considerable distance from shore. In the South it would appear to be somewhat more active in its habits, though frequently found on the oyster-beds, hiding between the valves of empty oyster-shells.

There are at least three distinct forms: (1) The northern variety, rarely exceeding ten, twelve, and even fifteen inches in length, the general color of which is brown coarsely marbled with darker marks. (2) The southern variety of Günther, which is found on the Florida Keys and in the Gulf, though often associated with the northern variety, which is similar in color to this, but has the body and the fins dotted and spotted with white. (3) A form found only in the Gulf, *Batrachus pardus*, which is much larger and of a light-yellow color spotted and blotched with brown. This form is known to the fishermen as the "Sarpo" and the "Sea-robin," the former name being doubtless a corruption of the Spanish word *sapo*, meaning toad. This form is said by Mr. Stearns frequently to attain the length of eighteen inches. The color of these fish usually corresponds very

[1] A closely related form, *Thalassophryne maculosa*, which occurs on the Atlantic side of the isthmus of Panama, has true poisoning glands at the base of its opercular spines, by means of which it can inflict injurious wounds; this being almost the only fish which possesses weapons of this character.

closely to that of the bottom upon which they are resting, and, like many other muddy-water species, they have the power of changing their color to lighter or darker shades when exposed to the light in shallow vessels with dark or light-colored bottom. They are very voracious, feeding upon small fishes of all kinds, especially upon anchovies and sand-smelt, and upon shells, crabs, shrimps, and marine worms. "It secures its food rather by strategy and stealth than by swiftness of motion," writes Mr. Stearns, "hiding under or behind stones, rocks, or weeds, or stealing from one cover to another it watches its victim until the latter is near by, when it darts forth with a quickness quite astonishing, considering its usual sluggishness, and back again to its hiding place, having one or more fish in its stomach and on the alert for others."

On the south coast of New England it is found chiefly in the shallow bays. "The sandy or *muddy bottom of these*," writes Storer, "*is overgrown with eel-grass, under cover of which it lives* in security and finds abundant sources of food. Where the coast, on the contrary, is more or less rocky, we meet with it chiefly under stones. Examining the places where the water is but a few inches in depth at low tide, we see that under many of the stones and smaller rocks the sand on one side has been removed, leaving a shallow cavity perhaps a foot in width and extending back beneath the stone. If we approach this cautiously we shall probably distinguish the head of a Toad-fish very much in the position of that of a dog as he lies looking out of his kennel. The fish is at rest, and might be overlooked by a careless observer; a closer attention, however, readily distinguishes the curve of its broad mouth and delicately laciniated tentacles with which its jaws and other parts of its head are ornamented. Its eyes, and sometimes the anterior portion of its body, are truly beautiful. At the slightest alarm it retreats beneath the stone, but presently reappears; it is lying here merely as in a safe resting-place, perhaps on the watch for its prey. But during the months of June, July, and August we shall in many instances be able to discover another purpose; it is apparently guarding its eggs or young; we shall then find on the interior surface of the stone the young Toad-fish adhering, to the number of several hundreds. They will be in different stages of development, according to the season of our examination. We may see the eggs not larger than very small shot; a little later they are increased in size, the young fish plainly visible through their walls; a little later still the young have made their escape, but are still attached to the stone. The attachment now, however, is accomplished in a different manner; the yolk not being yet absorbed, occupies a rounded sac protruding by a narrow orifice from the ~~abutment~~, and the part of this sac near its outer border being constricted leaves, externally to it, *a disc, by means of which, acting as a sucker, the young fish adheres so firmly as to occasion difficulty* in detaching it. They remain thus until they have attained the length of one-half or three-fourths of an inch, or until the yolk sac is entirely absorbed. During this period the adult fish occupies the cavity beneath the stone, and if driven from it speedily returns. The fish is in all cases the mother of the young ones, but that she is there for the purpose of guarding them we have no means of determining; we can only infer it."

At Noank, Connecticut, in 1874, I had an opportunity of watching the progress of the spawning season. July 14, numerous eggs were found clinging to the stones in water one to two feet in depth; later in the season, July 21, young fish, half an inch long, were plenty, and September 1 these had attained an average length of one inch. Individuals, apparently of the second year's growth, were also common, and would average three-fourths of an inch in length.[1]

[1] Silas Stearns writes: "In the Gulf of Mexico the Toad-fish spawns in April or May. When its young have been hatched, the older fish seem to guard them, and teach them the devices of securing food in much the same manner that a hen does her chickens. I have spent hours in watching their movements at this time, and was at first much surprised by the sagacity and patience displayed by the parent fish."

The bottom temperature of the water frequented by these fish would appear to range from 50° F. to 90° F. In the more northern regions throughout which they are distributed they appear to become torpid, or nearly so, in winter; and it is stated by Storer that they are frequently found in the mud by men spearing eels. They are very hardy, and when taken from the water will lie for many hours, and soon recover their ordinary activity when restored to the water. When handled they utter a loud croaking sound.

The Toad-fish is very abundant throughout the whole extent of its range, and is easily captured with hook and line. In the Gulf of Mexico many are taken in seines. Mr. Stearns states that its flesh is highly esteemed by many of the Gulf fishermen. Dr. Storer writes: "The Toad-fish is not commonly employed as an article of food. Its generally repulsive aspect causes it to be looked upon rather with disgust. That its flesh is delicate and good, however, can scarcely be questioned, though the small size which it attains and the fact that it never is taken in any large quantities prevent it from being of any economic value." Professor Baird also bears testimony to the fact that its flesh is very sweet and palatable.

The Toad-fish may be regarded as constituting one of the undeveloped resources of our waters, and it can scarcely be questioned that in future years it will be considered as much more important than at present. No estimates can be given as to the quantity now yearly entering into consumption, and, since it is almost never offered for sale, no price quotations can be presented. It has still another, and at present more important, relation to the fisheries than this; on account of its great abundance and its pertinacity in taking the hook baited for nobler game it is regarded by the fishermen as one of their worst pests.

The *Batrachidæ* are represented on the Pacific coast by the "Singing-fish," or "Toad-fish," *Porichthys porosissimus*. This fish lives on muddy bottoms from Alaska to Panama, and is everywhere extremely abundant. It reaches the length of eighteen inches, but being never used for food has no economic importance.

The family *Trichodontidæ*, which follows Batrachidæ in the classification of Gill, is represented on the California coast by the species *Trichodon Stelleri*, an estray from Alaska, rarely seen. On the Atlantic coast this family is entirely absent.

79. THE LUMP-SUCKERS; LUMP-FISH AND SEA-SNAILS.

The Sea Snails—Liparididæ.

The three families *Gobiesocidæ*, *Liparididæ*, and *Cyclopteridæ* are represented on our coast by several species, most of them minute and of no economic value; all of them characterized by the presence of a peculiar suctorial organ upon the belly, a modification of the ventral fins, by which they are able to cling to rocks and shells and to retain their positions in currents of water. The Lump-suckers, *Liparis lineatus* and *L. vulgaris*, which are found on oyster and scallop beds and among the roots of the kelp, and along the New England coast, are interesting from the fact that they are often parasitic, living within the shells of the large scallops, in company with a small crab resembling the oyster-crab. From the Chesapeake Bay southward, and in the Gulf of Mexico, allied forms belonging to the genus *Gobiesox* occur, especially among the oyster-beds, but these also are of no economic value.

The Lump-fish—Cyclopterus lumpus.

To this group belongs a fish which, though of little value, is often seen in our markets, and is so conspicuous, on account of its grotesque form and striking colors, that it is worthy of passing

mention. This is the common Lump-fish, *Cyclopterus lumpus*, known in England by the names "Lump-sucker," "Sea-owl," "Cock-paddle," and by numerous local appellations. This fish is widely distributed throughout the entire North Atlantic, ranging on our coast from the mouth of the Chesapeake to the Straits of Belle Isle, abundant in Greenland and Iceland, along the entire western coast of Scandinavia, from the North Cape to the Cattegat, entering the Baltic, and not rare along the shores of East and West Prussia, well known in Holland, Northern France, and everywhere in the British Isles. The largest English specimen recorded weighed eleven and a half pounds; the largest on our own coast, as observed by Storer, eighteen and three-quarters pounds.

"The Lump-fish," writes Benecke, "lives on the bottom of the sea, swims slowly and with difficulty, and in May and June comes into shallow water to spawn. The male makes pits in the sand, between the stones, in which the female deposits its eggs. The male watches over the eggs, and later over the tender young which cling to its body with their suckers. The number of eggs ranges from 200,000 to 400,000. It is a voracious species, which preys upon small crustaceans, mollusks, and fish-spawn."

Benecke's observations were made in the southern part of the Baltic; the spawning time is recorded by him as probably not very different from that in Southern New England. Young specimens from one-fourth to one inch in length are very abundant in Southern Massachusetts and Connecticut in July and August, swimming at the surface. They have not yet assumed the ponderous, unwieldy shape of the adults, and swim much more rapidly and gracefully. In Sweden, according to Malm, the spawning time is in June; "In England," says Yarrell, "in April and the beginning of May"—dates which correspond precisely to those given by Fabricius for Greenland.

The male Lump-fish is said to be very fierce in defense of its young, and to be able to protect them from much larger fish than themselves, even from the wolf-fish. It is, in its turn, a favorite prey for the seals and wolf-fish. At the time of the spawning season the ordinary translucent green color of the body becomes much brighter, and the under parts of the fish are of a brilliant red. After spawning, the red disappears and the general color of the body becomes dull. When in the season of the brightest coloration they are frequently shown in the fish markets, where their remarkable appearance attracts much attention.

"If the authority of Sir Walter Scott is to pass current in gastronomy," writes Richardson, "Lump, or *Cock-paidle*, as it is named in Scotland, is a fish of good quality, for he makes Mr. Oldbuck give the same price for one that he does for the bank-fluke or turbot."

Parnell states: "On the west coast of Scotland sometimes as many as two dozen are taken in the salmon nets at almost every tide, principally in the month of June, when they seek the sandy ground to deposit their spawn. The fishermen boil them down with vegetables for their pigs, and consider them to be fattening food. The flesh, when cooked, is soft and very rich, and is considered by some of the inhabitants of Edinburgh as a luxury; but there are few stomachs with which it agrees, in consequence of its oily nature. The males are considered the best for the table." In Scotland it is also sometimes eaten in a salted state.

Buckland also has an opinion on record: "So great is the difference between the different specimens that our fishermen consider them to be distinct species and call them the "Red-lump" and the "Blue-lump," but the difference in color and flavor is only the effect of the season. I do not like the flesh at all myself; it is like a glue pudding."

It is stated that the Greenlanders eat the flesh either cooked or dried and the skin raw, while they eat the roe, which is remarkably large, after having reduced it by boiling it to a pulp.

Perley records that "In the spring the Lump-fish approaches the shores of New Brunswick

and Nova Scotia to deposit its spawn. It is then taken in considerable numbers near the harbors at Halifax, the largest weighing about five pounds. They are taken there of two different colors, the one being a dark blue approaching to black, and the other quite red. Those of a red color only are used as food; they are considered good by many, although very fat and somewhat oily; the dark-colored is considered very inferior and is not eaten."

On the Pacific coast the *Gobiesocidæ* are represented by *Gobiesox reticulatus* (Grd.) J. & G., a small fish four or five inches long, adhering to rocks by a sucking disk on the breast. It is found from Monterey northward, and has no economic value. The *Cyclopteridæ* are represented by the rare *Cyclopterus orbis* occasionally taken in the Straits of Fuca and northward. The *Liparididæ* are represented by *Liparis pulchellus* Ayres, and *Neoliparis mucosus* (Ayres) Steindachner, small fishes occasionally taken about San Francisco and Monterey, of no economic importance.

80. THE GOBIES—GOBIIDÆ.

The Goby family is represented on the Atlantic coast by several species, none of which have ever been found north of Cape Cod, and none of which are or ever can be of the slightest importance. Chief among these are the scaleless Goby, *Gobiosoma alepidotum*, which is found between Cape Cod and Texas; the Chubby Goby, *Gobius soporator*, common along the Gulf coast, and several species belonging to the genera *Eleotris* and *Dormitator*. They are not even abundant enough to be worthy of consideration as food for other fishes. On the Pacific coast there are several small species, which may be seen lying on the bottoms entering the lagoons. They reach the length of three to six inches, and are of no economic importance, though the Chinese eat the Long-jawed Goby, *Gillichthys mirabilis*, and its flesh is said to be very good. The other species are *Gobius glaucofrænum* (Gill) J. & G., in Puget Sound; *Lepidogobius gracilis* (Girard) Gill, from San Francisco northward; *Eucyclogobius Newberrii* (Girard) Gill, rarely seen about San Francisco, and *Gillichthys mirabilis* Cooper, found the entire length of the coast, but abundant only from San Francisco southward. The latter species burrows in the muddy bottoms of the lagoons.

81. THE SEA-ROBIN OR GURNARD FAMILY—TRIGLIDÆ.

This family is represented on our Atlantic coast by several species, some of them being quite abundant. The most striking of them all is the Sea-bat or Flying Gurnard, *Dactylopterus volitans*, which is remarkable on account of its enormous spreading fins, larger than those of a flying-fish—wings which, however, are not sufficiently powerful to lift the body above the surface of the water, though useful in maintaining the equilibrium of the heavy-headed body swimming through the water. The colors of the body and of the fins are very brilliant, and the fish is often exhibited as a curiosity. It is found along our entire coast south of Cape Cod, and in the waters of Brazil; also in the Mediterranean and in the neighboring parts of the Eastern Atlantic.

The genus *Prionotus*, of which we have five specimens, resembles *Dactylopterus* in general form, but the wings are much smaller, while two or three of the lower rays of these fins are developed into finger-like appendages which are used in stirring up the weeds and sand to rout out the small animals upon which they feed. In Southern New England there are two large species, *P. palmipes* and *P. evolans*, the latter distinguished by the presence of dark stripes upon its sides. These attain the length of fifteen to eighteen inches and the weight of one and a quarter to two pounds. They have excellent food qualities, but are eaten, so far as we have record, only in the vicinity of Hartford, Connecticut, where they are known as "Wing-fish." They are taken in great quantities in the pound-nets along the Vineyard Sound, especially the unstriped species, the habits

of which are better understood than those of the allied species. It feeds upon crabs, shrimps, and small fishes.[1]

In Vineyard Sound the Sea-robin spawns during the summer months. A specimen obtained at Wood's Holl, August 12, 1875, contained eggs nearly ripe. Another, observed at Noank, Connecticut, July 11, 1874, was in precisely the same condition. Lyman states that in 1871 the eggs, which are bright orange, were thrown up in quantities during the last third of May on the beach *on the inner parts of Waquoit Bay, and the females had well developed spawn in them.*

The species just mentioned are found as far north as Cape Cod; the web-fingered Sea-robin, *P. palmipes*, even north of the cape, two or three specimens having been obtained in the vicinity of Salem and Lynn. These two species apparently do not occur much to the south of Cape Hatteras, and on our Southern coast they are replaced by others which are smaller and, at present, of no *economic importance.*[2] The genus *Prionotus does not occur in Europe, the family being there represented* by a very similar form, genus *Trigla*, which, however, has still smaller wings. Its habits are much the same. A single specimen of the Red Gurnard of Europe, *Trigla cuculus*, is said to have once been taken at New York. Europe has nine species of *Trigla*, most of which are highly esteemed for food; some of these species have been known to attain the length of two feet and the weight of eleven pounds. These fishes are held in high estimation, and are frequently seen in the markets.

USES.—Parnell writes: "The Red Gurnard occurs on the Devonshire coast in great numbers, *and on some occasions thousands of them may be seen exposed for sale daily, especially in those* small towns where the trawl-boat fishing is carried on. The flesh is firm and well-flavored. The Tub-fish, *T. hirundo*, is of frequent occurrence on the west coast of Scotland, and is occasionally brought to the Edinburgh market. Its flesh is firm and wholesome, and is considered by some to be superior to the last species, but in general more dry. In the north of Europe it is salted for *keeping. The Gray Gurnard, T. gurnardus, is considered by all fishermen richer and sweeter than* any of the other Gurnards, although in the markets it is less sought after than the Red Gurnard, which is the drier and worse flavored of the two. It is taken generally with hooks baited with mussels. These fish are taken in very great numbers in the trawl-nets; they appear to be much more abundant on the European coast than their cousins, the Sea-robins, with us."[3] Their recommendations *are quoted here in order to draw attention to this neglected group of fishes*, which are certainly worthy of greater consideration than they have hitherto received.

Mr. J. Carson Brevoort has given the following testimony regarding the food qualities of the American species:

"*The Gurnard as an edible fish.*—Among the fish that may be classed as edible, but which are entirely neglected here, is the Sea-robin, Grunter, or Gurnard. This curious, but rather forbidding creature, is, in reality, one of the most delicate morsels that can be laid before an epicure, the flesh being snow-white, firm, and fully as good as that of the king-fish, or whiting. In fact it would be hard to distinguish them when placed on the table.

"In Europe every one of the various kinds of Trigla, or Gurnard family, is sought after eagerly, and finds a ready sale on the fish-stalls. They have eight or ten kinds of the group there, and we have but six here; all but one different from the European kinds, though belonging to the same

[1] Specimens caught at Wood's Holl, Massachusetts, May 29, 1871, contained shrimp, *Crangon vulgaris*, and a small flounder. Another, taken May 29, contained a small beach-flea, *Anonyx, sp.*, and *Crangon vulgaris*. Others, dredged in Vineyard Sound in August, contained crabs, *Panopeus Sayi*, *Cancer irroratus*, and small fishes. Another, taken at Noank, Connecticut, in July, 1874, contained sand-fleas, *Unciola irrorata* and *Ampelisca sp.*

[2] A single specimen of *S. palmipes* was taken by Mr. C. H. Gilbert, at Charleston, South Carolina, in 1882.

[3] PARNELL, RICHARD: Fishes of the Firth of Forth, 1838, p. 174.

family. We shall not attempt to describe all these fish, which resemble each other very much in all but the color. They all have large heads, sheathed with rough, bony plates, and armed with many acute points, and their dorsal fin has also several sharp, thorny rays. These prickles are all erected by the fish when taken alive, and they inflict a painful, though not, as many say, a poisonous wound. The broad mouth is furnished with rough, but not sharp, teeth; the pectoral fins in most of the species are very long, and can be expanded like a fan, whence they are sometimes called Flying-fish and Butterfly-fish. It is doubtful, however, whether they can actually fly like a flying-fish, but they have been said to skip from wave to wave, a peculiarity often alluded to by halieutic poets. They also emit a grunting sound, which can be distinctly heard in still weather while lying at anchor on a shallow, which they frequent. At such a time the sound resembles the distant lowing of kine. When freshly taken from the water they grunt quite loudly, whence their popular name of Grunter, or Cuckoo-fish.

"The Gurnards live on crabs and delicate fresh food, taking all such baits readily, on a clean bottom, and they sometimes annoy fishermen hugely by their voracity. They play well on the hook, and a large one tugging at a rod is often supposed to be a game fish and a prize, till the ugly Sea-robin, with his spiky helmet, shows himself at the surface.

"The Gurnards of our coasts do not reach a large size, at least we have but rarely seen any that weighed over a pound, while in Europe some of the species, such as the Tub-fish, *Trigla hirundo*, have been found weighing eleven pounds, and those of seven or eight are common. The Red Gurnard, or Rotchet, *T. cuculus*, and the Piper, *T. lyra*, reach three or four pounds, averaging about two, while the other European kinds resemble ours as to size.

"Small as our species are, they are not the less delicate when cooked, and we have often verified this fact. They are sold in England by the number, and not by weight, for their large heads are inedible, while they add, perhaps, one-quarter to their weight. The English fishermen take them almost everywhere along the coast in large trawl-nets, constructed for their capture, though other bottom fish may find their way into the net. These trawls are generally twelve or sixteen feet wide at the mouth, with a bag proportioned to their beam, which has one or two labyrinths like a fyke-net inside. The trawl is managed from a large sail-boat, with a block and tackle, and is hauled in water as deep as eight or ten fathoms. We do not recommend this special fishery to our coast fishermen, as our Gurnards are small, but wish only to call attention to the edible qualities of this generally despised fish.

"Piscator (the anonymous author of the 'Practical Angler'), in his excellent little treatise entitled 'Fish; How to Choose and How to Dress,' published in 1843, says of the Gurnard that their flesh is 'white, excellent, exceedingly firm, and shells out into snowy flakes, and is of a remarkably agreeable flavor,' and that 'they keep well.' He recommends them to be boiled—that is, the large ones; while the small ones may be split and fried.

"We have no popular names for the species that are found in our waters. All are called Sea-robins, Flying-fish, Grunters, &c.

"Having drawn attention to this first as one that deserves a place on our tables, we leave his fate hereafter to the tender care of a good cook and a discerning palate."

Another member of this family is the *Peristedium miniatum* Goode, a brilliant red species recently discovered by the Fish Commission in the deep waters on the coast of Southern New England.

THE AGONUS FAMILY.—Another family closely related to the family *Triglidæ* is the family *Agonidæ*, the members of which are remarkable on account of their angular bodies encased in spinous, bony plates; it is represented on our east coast by one species. The *Aspidophoroides*

monopterygius—the "Greenlander," as it has been christened by the seamen on the Fish Commission steamer—has been observed as far south as Watch Hill, Rhode Island, and is quite abundant in deep water north to the polar regions, having been frequently observed on the coast of Greenland. This fish attains a length of seven or eight inches, and, although it is not much thicker or softer than an iron spike, is sometimes found in the stomachs of codfish and halibut.

"On the Pacific coast," writes Professor Jordan, "the Agonidæ are represented by numerous species inhabiting deep waters from Santa Barbara northward. They have no economic importance, being brought into market only by accident. These species are *Leptagonus verrucosus* (Lockington), J. & G.; *Leptagonus xyosternus*, J. & G.; *Podothecus acipenserinus* (Pallas), J. & G.; *Podothecus vulsus*, J. & G.; *Odontopyxis trispinosus* Lockington; *Bothragonus Swani* (Steind.), Gill, and *Aspidophoroides inermis* Gthr. The Triglidæ are represented by *Prionotus stephanophrys* Lockington; rarely seen at San Francisco."

82. THE SCULPIN TRIBE—COTTIDÆ.

SCULPINS OF THE ATLANTIC COAST.—On our Atlantic coast are found several species of this family, generally known by the name "Sculpin," and also by such titles as "Grubby," "Puffing-grubby," "Daddy Sculpin," "Bullhead," "Sea-robin," "Sea-toad," and "Pig-fish." Their economic value is little or nothing, but they are important as scavengers, and are used for lobster bait. They are often a source of great annoyance to the fishermen by cumbering their hooks and by stealing their bait. The most abundant species is the Eighteen-spined Sculpin, *Cottus octodecimspinosus*, which frequents shallow and moderately deep waters from Labrador to New York. It is usually associated with a much smaller species, *Cottus æneus*, which may be called the "Pigmy Sculpin," and which ranges from the Bay of Fundy to New York.

Cottus scorpius, of Europe, is represented on our coasts by *C. scorpius* subsp. *grœnlandicus*, which is abundant everywhere from New York to Greenland and Labrador. This subspecies has been found on the coast of Ireland,[1] and the typical *Cottus scorpius* has been shown by Dr. Bean to occur in Maine. There is also, in addition to several insignificant species seldom seen except by naturalists, a large, brilliantly colored form, known as the "Sea-raven," "Rock Toad-fish," or "Deep-water Sculpin," which is found as far south as the entrance to Chesapeake Bay, is abundant throughout New England, and has been discovered off the coast of Nova Scotia. This fish, *Hemitripterus hispidus*, or *H. americanus*, attains the length of two feet, and is conspicuous by reason of its russet-orange or brick-red colors, its harlequin-like markings, its warted body, its grotesquely elongated fins, and, above all, by its peculiar habit of swallowing air until its belly is inflated like a balloon.

These fishes feed upon all bottom animals, mollusks, crustaceans, sea-urchins, and worms, and may also be found in the harbors devouring any refuse substances which may be lying upon the bottom. They breed, for the most part, in summer, and certain species, like the Sea-raven and the Greenland Sculpin, at that time assume very brilliant colors. They are not eaten by our people, although the Sea-raven is decidedly palatable. Those species which occur in Greenland are said to be eaten by the natives. As has been remarked, they are a source of annoyance to fishermen, whose bait they steal and whose hooks, especially the hooks of their trawl-lines, they encumber. Boys delight to catch them and fix a piece of light wood between their teeth; they are then unable to swim and struggle vigorously at the top of the water.

About the fish-curing stations they are very abundant, and exceedingly useful as scavengers,

[1] *Annals of Natural History*, 1841, p. 402.

gorging themselves with refuse thrown back into the sea; they care little for the presence of man, and can hardly be driven away, even when roughly punched with a boat-hook.

In the lakes and streams of the Northern States are numerous species of *Uranidea* and allied genera, known in some localities by the English name of "Miller's Thumb," also called "Bull-heads," "Goblins," "Blobs," and "Muffle-jaws." They are small and of no importance except as the food of larger species.

SCULPINS OF THE PACIFIC COAST.—The Cottidæ, according to Jordan, are represented on the Pacific coast by about eighteen separate species, known by such names as "Sculpin," "Drummer," "Salpa," "Johnny," "Biggy-head," and "Cabezon." Only one of these species, *Scorpænichthys marmoratus*, has any sort of economic importance; the others may be considered collectively. The names applied to them may be briefly considered. The name Sculpin, of course, is derived from that in use for the Atlantic species of Cottus. "Drummer" comes from the quivering noise made by many species when taken alive out of the water. "Salpa" is a Spanish word for toad, and applied also to species of Batrachidæ. "Johnny" is applied only to very little Sculpins along the shore, notably *Oligocottus maculosus*. The same name is given in the Ohio Valley to fishes of precisely similar habits, the *Etheostomatinæ*. "Biggy-head" and its Spanish cognate "Cabezon" are used by the Italians and Spanish about Monterey, Santa Barbara, and elsewhere, for different Cottidæ.

Most of the Cottidæ feed upon small fishes, and especially crustacea; one species, *Enophrys bison*, being a vegetable feeder. All take the hook readily. The flesh is poor, tough, and dry, and the waste by the removal of the head, viscera, and skin is so great that even the poorest people do not use them as food. Various sorts (notably *Leptocottus armatus*) are dried by the Chinese, who consider them the poorest of all dried fishes.

The species are: *Psychrolutes paradoxus* Gthr., found from the Straits of Fuca northward; *Ascelichthys rhodorus* Jor. and Gilb., also chiefly northward; *Cottus polyacanthocephalus* Pallas, one of the largest species, from Cape Flattery northward; *Artedius lateralis* Grd., found among the rocks from Monterey northward; *Artedius notospilotus* Grd., in the kelp, etc., from Santa Barbara to San Francisco; *Artedius fenestralis* Jor. and Gilb., about Vancouver's Island; *Artedius quadriseriatus* Lockington and *Artedius megacephalus* Lockington, taken in deep water off San Francisco; *Artedius pugettensis* Steind., in deep water from Puget Sound northward; *Hemilepidotus spinosus* Ayres, found chiefly about San Francisco and Monterey, and the large *Hemilepidotus trachurus* (Tilesius), ranging from San Francisco to Alaska; *Enophrys bison* Grd., a large species, the sole member of the group feeding exclusively on plants, ranging from San Francisco to Alaska, and exceedingly abundant in Puget Sound; *Scorpænichthys marmoratus* Grd., noticed below; *Leptocottus armatus* Grd., the commonest of all the species, abundant in every bay; *Liocottus hirundo* Grd., and *Oligocottus analis* Grd., two species ranging chiefly southward; *Oligocottus globiceps*, Grd., and *Oligocottus maculosus* Grd., small and active inhabitants of the rock pools northward; and, finally, the curious *Blepsias cirrhosus* (Pallas) Gthr., *Nautichthys oculofasciatus* Grd., and *Rhamphocottus Richardsoni* Gthr., Alaskan fishes straggling southward to San Francisco. In the fresh waters and often running into the sea are *Uranidea aspera* (Rich.) J. and G., and *Uranidea gulosa* (Grd.) J. and G., found in all the streams north of the San Joaquin. Only one of this numerous series merits especial consideration, namely the "Cabezon," *Scorpænichthys marmoratus* (Ayres) Grd. The names "Cabezon," "Sculpin," "Scorpion," "Salpa," and "Biggy-head" are applied to this species. The latter is heard chiefly among the Italians, who have about Monterey and elsewhere adopted the Spanish "Cabezon," which appears to be the most distinctive term. The names "Sculpin," "Scorpion," and "Salpa" are applied to various other species, and are rather collective than specific names.

This species reaches a length of more than two feet, and a weight of more than ten pounds, being by far the largest member of its family on the Pacific coast. It is found from San Diego to Victoria, but is more abundant about Monterey and San Francisco than either northward or southward. It inhabits moderate depths, and is taken in considerable numbers with gill-nets and hooks. It feeds upon crustacea and small fish. Its value is very small, the flesh being tough and flavorless, and it is rarely sent to the market when good fish are abundant.

83. ROSE-FISH OR RED PERCH—SEBASTES MARINUS.

Although upon the west coast of North America the fishes of the family (*Scorpænidæ*) are among the most important, there are only four species on the Atlantic coast of North America; of these, two have been discovered within the past year, and the others, though well known and very widely distributed, are not of great importance. The Rose-fish, *Sebastes marinus*, is conspicuous and unique among cold-water fishes by its brilliant scarlet color; it is also known as "Red Perch,"[1] "Norway Haddock," "Hemdurgan," and "Snapper," as "Bream" in Gloucester, Massachusetts, and called "John Dory" in Halifax, Nova Scotia. It is found also in Northern Europe, where it has been recorded as far south as Newcastle, in Northern England, latitude 55°,[2] and it has also been found in Aberdeen and Berwick, and in Zetland, where it is called "Bergylt" and "Norway Haddock."

On the eastern side of the North Sea the species has not been seen south of Gothenborg, latitude 58°, but is said to be abundant along the entire western coast of Norway to the North Cape and Varenger Fjord in East Finmark, while Malmgren records it from Bären Island, and Scoresby found it at Spitzbergen, latitude 80°. In Iceland it is abundant, and in Davis' Straits, at least as far north as Disco, where it is found associated with the halibut, and is said to constitute a liberal share of its food. In Eastern Labrador, about Newfoundland, and in the Gulf of Saint Lawrence, it is abundant, and also along the shores of Nova Scotia and in the Bay of Fundy. In these northern regions the Rose-fish prefers shallow water, and may be taken in the greatest abundance in the bays and around the wharves in company with the sculpins and the cunner or blue perch. On the coast of the United States, south of the Bay of Fundy, they are rarely seen near the shore, but have been found in deep water in all parts of the Gulf of Maine and Massachusetts Bay, and also abundantly south of Cape Cod. In the fall of 1880 the United States Fish Commission obtained great quantities of them, young and old. DeKay included this fish in his New York list, stating, however, that it was very rare in those waters. He remarks that "the coast of New York is probably its extreme southern limit."

Of late years none have been taken south of the locality already mentioned, which was in water from one to three hundred fathoms in depth, at the inner edge of the Gulf Stream, from fifty to one hundred miles southwest of Newport, and about the same distance east of Sandy Hook. A hundred or two hundred miles farther south it is replaced by a fish resembling it somewhat in form and color, *Scorpæna dactyloptera* De la Roche, discovered by the Fish Commission during the past year, and by *Scorpæna Stearnsi*, detected at Pensacola by Silas Stearns, and at Charleston by C. H. Gilbert.

It may fairly be said that the Rose-fish, as a shore species, is not known south of parallel 42°, which is 13° south of its transatlantic limit. When the deep waters of Southern Europe have been as carefully explored as those of the United States, it is probable that the range of this fish will be extended considerably farther to the south.

[1] In distinction from the "blue perch" or "cunner" (*Ctenolabrus adspersus*), which it resembles in form, but not in color.

[2] GÜNTHER; Cat. Fishes Brit. Mus. 2, p. 96.

The temperature range of the Rose-fish corresponds closely to that of the halibut, and its limits will, on more careful study, probably be found included between 32° and 50°. It is found everywhere on the shallow off-shore banks north of Cape Cod, where it attains its greatest size. A specimen, brought in by one of the Gloucester halibut schooners, was about two feet in length and weighed about fourteen pounds. Along the Maine coast they are much smaller than this, rarely exceeding eight or ten inches and the weight of twelve ounces, but occasionally growing to the weight of one and a half pounds.

In Scandinavia there have been recognized two species: one, a large, orange-colored form, inhabiting deep water, known to the Norwegians as the "Red-fish" (Röd-fisk), and considered to be *S. marinus* (*S. norvegicus*); the other, a smaller species of much deeper color, called the "Lysanger," and described by Kroyer under the name "*S. viviparus*," and by Ekström as "*S. regulus*." After the most careful study of all the specimens in the National Museum, we have been unable to recognize more than one species on our coast, and recent Norwegian ichthyologists, among them especially Mr. Robert Collet, believe that the two Norwegian forms are not actually distinct species, but that the smaller one is simply a pigmy race which is especially adapted to life in the long, shallow fiords of that region. Dr. Lütken, always conservative, is inclined to believe the two forms distinct, regarding the large fish of the deep water as the primitive type from which the smaller littoral form has been derived by development. According to the last-mentioned authority, the two forms have very different geographical distribution, *S. viviparus* inhabiting the shallows in the vicinity of the Faroe Islands, Southern Sweden, Norway, and New England, but unknown to Great Britain, Denmark, Finmark, Iceland, and Greenland; while *S. marinus* is found in Greenland and Iceland and all the length of the Norwegian coast, in Spitzbergen, Bären Island, on the coasts of Denmark, and occasionally in the north of England and Ireland. Possibly, he suggests, it inhabits the deep waters at a distance from shore, off the Faroe Islands and North America, but that is not yet certainly known. *S. viviparus*, then, he declares, is a form less arctic as well as more littoral.[1]

This subject is here referred to in the hope that additional observations may be drawn out tending to settle the question whether or not there are two forms of *Sebastes* on the American coast. It seems, however, improbable, since the physical conditions are so different from those under which they occur on the other side of the Atlantic.

The food of the Rose-fish consists, like that of its cousins, the Sculpins, of small fish, crustaceans, and, to some extent, of mollusks, although its teeth are not formed for crushing the thick-shell species. In Greenland they are said to feed upon the pole-flounder. A specimen taken off Eastern Point, Gloucester, in July, 1878, had its throat full of shrimp-like crustaceans (*Mysis* sp.), and others, taken at Eastport, were feeding extensively on a larger crustacean (*Thysanopoda* sp.), which is also a favorite food of the mackerel. They may be caught with almost any kind of bait, but are not, like their associates, the cunners, given to feeding upon refuse substances, and, being also more shy and watchful, cannot be captured in bag-nets. They breed in summer, from June to September, in deep holes in Massachusetts Bay and off the coast of Southern New England, where it has not been uncommon for the Fish Commission to obtain thousands of young one, two, and three inches long, at one set of the trawl-net, and also adults full of spawn. The young are lighter in color than the adults, and are conspicuously banded with reddish-brown upon a grayish ground. The young constitute a favorite food of the codfish, while, at all ages, they are preyed upon by the halibut and other large predaceous fishes of the cold-water districts.

[1] 1879. LÜTKEN, CHR.: Forelöbige Meddelelser om nordiske Ulkefiske (Cottoidei). <Aftryk af Vidensk. Meddel. naturh. Foren. 1870, pp. 355–388.

Although the Rose-fish is much esteemed as an article of food, and is caught in considerable numbers all along the coast of Maine and the British Provinces in the season when it frequents the shallows near the shore, and in winter at Gloucester when flocking in large numbers into the harbor, the most extensive fisheries are probably on the coast of Greenland, where they are highly prized by the natives, who feed on the flesh and use the spines of the fins for needles, and in Massachusetts Bay, where great quantities are taken by the Irish market-fishermen on trawl-lines. In winter they are occasionally found in the New York markets, and on one or two occasions have been brought in considerable numbers to New Haven, and even to Philadelphia. The flesh is firm, rich, and delicate in flavor; the young fish, fried crisp, make an excellent substitute for white-bait.

84. THE ROCK CODS OF THE PACIFIC.

By DAVID S. JORDAN.

[On the Pacific coast, as has already been stated, the fishes of this family, known as Rock-cod and Rock-fish, are of great importance. They are discussed at length by Professor Jordan, who writes:]

One of the most remarkable features of the Californian fish fauna is the enormous abundance both in individuals and in species of the group of Scorpænidæ. All of them are excellent food-fishes, and scarcely a boat returns from any kind of fishing in which these fishes do not form a conspicuous part of the catch. In every fish-market they are found, and from their large size and brilliant coloration they are everywhere the most conspicuous fishes on the stalls.

These fishes have so many traits in common, that a review of the group as a whole is desirable before we proceed to the consideration of the several species.

NAMES.—These fishes are universally known by the names of Rock-fish and Rock-cod. The latter name is the one most commonly heard, the other name being apparently a reaction against the obvious error of calling these fish "Cod." The name Rock-fish is an appropriate one, and in time it will probably supplant that of Rock-cod. The name Cod or Cod-fish is never applied to them without the accompanying "Rock." In the southern part of California, the name "Garrupa" or "Grouper" is in common use, especially for the olivaceous species. This is a Portuguese word, and belonged originally to the species of *Epinephelus* and related genera. Different species have also special names, mostly given by the Portuguese fishermen. These are noticed below.

The average size of the species of the group is about fifteen inches in length, and a weight of two or three pounds. Some of them reach a length of nearly three feet, and a weight of twelve pounds. Nothing is known of their rate of growth.

The greatest abundance both of individuals and of species in this group is to be found from Santa Barbara to San Francisco, the maximum about Monterey. They occur from Cerros Island, where they are rather scarce, at least as far as Kodiak, and other species similar are found on the coasts of Japan, Chili, etc. The individuals are extremely local. Most of the species are found about rocky reefs, often in considerable depths, and they probably stray but little from their abodes. In general, the red species inhabit greater depths than the brown or green ones, and the latter swim about more freely. Their abundance on certain reefs about Monterey and the Farallones is doubtless being diminished; elsewhere there has been little danger of overfishing. All are predatory and voracious, feeding mainly upon other fishes, and sometimes on crustaceans.

All of the species are ovo-viviparous. The eggs are small and exceedingly numerous, and are hatched within the body. The eggs themselves are bright yellow. In the spring, at a season varying with the latitude and perhaps with different species, these yellow eggs turn to a grayish color.

If then examined, the two eyes of the young fish can be distinctly seen. Later a slender body appears, with traces of vertical fins, the length then being about one-fourth to one-third of an inch. They are probably extruded at about the length of one-third of an inch, and in a very slender and pellucid condition, as I have never seen them in any more advanced stage of development. Nothing is known of the modes of copulation, nor of the circumstances under which the young are excluded, but the time of breeding is probably for the most part in May. Young fishes of one and a half to two inches are common in August, and in the fall they are large enough (S. *paucispinis*, *flavidus*) to be taken with hook and line from the wharves. Individuals of less than six or eight inches are rare in the spring, and the fish of that length are probably a year old.

The enemies of these fishes are of course their predatory neighbors, and the larger individuals prey upon the smaller. The hag-fish (*Polistotrema*) destroys considerable numbers. They are usually very free from internal parasites.

All the members of this family rank high as food-fishes. The flesh is firm and white, and, although not very delicate, is of a fair quality. That of *Scorpæna guttata* is probably best; that of *Sebastichthys mystinus* brings the lowest price in market, but the prejudice against the latter species perhaps rests on its color.

SCORPENE (*Scorpæna guttata* Girard).—This species is known by the names "Scorpene," "Scorpion," and "Sculpin." "Scorpene" (Scorpina), in common use among the Italian fishermen, is, of course, the name of *Scorpæna porcus*, *S. scrofa*, and other Mediterranean fishes, transferred to this very similar North American fish. The wound made by the dorsal spines of this fish is excessively painful, far more so than the sting of a bee, as though the spines had some venomous secretion. The name *Scorpæna* is evidently derived from this. This species reaches a length of something over a foot and a weight of about two pounds. It is found only from Point Concepcion southward to Ascension Island, living about rocks and kelp, but often entering the bays. It is generally common, and takes the hook freely. It feeds upon crustacea and small fishes, and spawns in spring. Nothing distinctive is known of its breeding habits. As a food-fish it ranks with the best, being superior to the species of *Sebastichthys*, and it always is in good demand where known.

BLACK-BANDED ROCK-FISH (*Sebastichthys nigrocinctus* (Ayres) Gill).—This species has, so far as we know, received no distinctive name from the fishermen. It reaches a weight of about four pounds and a length of eighteen to twenty inches. It ranges from Monterey northward, being found only in deep water (ten to twenty fathoms). About San Francisco it is exceedingly rare, not half a dozen usually coming into the markets in a year. In the Straits of Fuca and outside in the open ocean it is tolerably abundant. The food and the breeding habits, so far as known, differ little in this family, and the general remarks on the group apply to all the species of *Sebastichthys*. As a food-fish this species sells readily on account of its brilliant and attractive colors, second only in brilliancy to those of the "Spanish Flag."

TREE-FISH (*Sebastichthys serriceps* Jor. & Gilb.).—Wherever this species receives a distinctive name, it is known as the "Tree-fish," an appellation originating with the Portuguese at Monterey, and without obvious application. Southward it is confounded with other species as a Garrupa. Its size is rather less than that of *S. nigrocinctus*, which it much resembles. It ranges from San Martin Island to San Francisco, being found in rather deep water among rocks. It is most common about the Santa Barbara Islands and is rare in the markets of San Francisco. It is a handsomely-colored species, and therefore sells well in the markets.

SPECKLED GARRUPA (*Sebastichthys nebulosus* (Ayres) Gill).—This species is known as "Garrupa" and "Rock Cod," rarely receiving any distinctive name. It reaches a weight of three and one-half pounds. It ranges from Monterey to Puget Sound, being generally common at all points,

and most abundant northward. It lives in water of moderate depth. It forms about two per cent. of the total rock-fish catch, and is always readily salable. It is the most attractive in color of any of the dark-colored species.

BLACK AND YELLOW GARRUPA (*Sebastichthys chrysomelas* Jor. & Gilb.).—This species also is confounded under the names "Garrupa" and "Rock-cod." It is one of the smaller species, reaching a weight of about two pounds. It ranges from San Nicolas Island to San Francisco, and is generally common in water of moderate depth, although not one of the most abundant species. It is an attractive fish in color and therefore readily salable.

FLESH-COLORED GARRUPA (*Sebastichthys carnatus* Jor. & Gilb.).—This species reaches a somewhat larger size than the last, and ranges from Santa Barbara to San Francisco. About San Francisco it is considerably more abundant, forming nearly seven per cent. of the total rock-fish catch.

YELLOW-BACKED ROCK-FISH (*Sebastichthys maliger* Jor. & Gilb.).—We have heard no distinctive name for this species. It ranges from Monterey to Puget Sound, in rather deep water. It is not very common about San Francisco, but many are caught in the Straits of Fuca. It is one of the largest of the species, reaching a weight of six or eight pounds. As a food-fish it is not as good as some of the others.

RED GARRUPA (*Sebastichthys caurinus* and subsp. *vexillaris* Jor. & Gilb.).—This species is known as "Garrupa," "Rock-fish," and "Rock-cod." It reaches a length of twenty inches and a weight of six pounds. It ranges from San Nicolas to Puget Sound, being generally common in water of moderate depth. It is subject to greater variations than any of the other species in the different parts of its range. It forms about seven per cent. of the total rock-cod catch. Its flesh ranks as about average.

GRASS ROCK-FISH (*Sebastichthys rastrelliger* Jor. & Gilb.).—This species, like all those of dusky color, is known as "Garrupa." At San Francisco it is often called "Grass Rock-fish," perhaps from its color. It reaches a weight of two to four pounds. It lives in water of moderate depth, and is rather common everywhere from San Nicolas to Humboldt Bay. Its abundance is greatest south of Point Concepcion. It is said to be the best of all the Rock-fish for the table, and to be an especial favorite with the Jews.

BROWN ROCK-FISH (*Sebastichthys auriculatus* (Girard) Gill).—This species seldom receives a distinctive name from the fishermen. It reaches a weight of three or four pounds, although as usually seen in the markets it is smaller than any other of the species. This is owing to the fact that its young are caught in seines in the bay, while those of other species are less frequently taken, and then only in the open ocean. It ranges from San Martin Island to Puget Sound, living in shallow water and entering all the bays, and being taken with a hook from all the wharves. It is thus apparently more abundant than any other species, although in actual numbers probably many of the deep-water forms (*S. flavidus, pinniger, rosaceus*) far exceed it. As a food-fish it is held in lower esteem than most of the others.

PESCE VERMIGLIA (*Sebastichthys chlorostictus* Jor. & Gilb.).—This species is known as "Pesce Vermiglia," or "Vermilion-fish," by the Portugnese fishermen at Monterey. It is known only from Monterey Bay and the Farallones, occurring about the rocks in considerable depths of water and being taken only with the hook. In its native haunts it is not a rare species. It reaches a weight of three or four pounds, and is excellent food.

FLY-FISH (*Sebastichthys rhodochloris* Jor. & Gilb.).—The inexplicable name of "Fly-fish" is given to this species by the fishermen at Monterey. Like the preceding, it is known only from very deep

water about Monterey and the Farallones. It is one of the smallest species, rarely weighing more than a pound.

CORSAIR (*Sebastichthys rosaceus* (Grd.) Lock).—This species is known to the Portuguese fishermen at Monterey by the name "Corsair," a name of unknown application transplanted from the Azores. It is one of the smallest species, rarely weighing more than a pound and a half. It ranges from Santa Barbara to San Francisco, in deep water, and, where found, it is the most abundant of the red species. When the weather permits outside fishing with trawl-lines, this is one of the most abundant species in the San Francisco markets. It ranks high as a food-fish.

SPOTTED CORSAIR (*Sebastichthys constellatus* Jor. & Gilb.).—In size, distribution, habits, and value this species agrees with the "Corsair." It is, however, considerably less abundant, although not a rare fish in the markets of San Francisco.

YELLOW ROCK-FISH (*Sebastichthys umbrosus* Jor. & Gilb.).—Two specimens only of this species are known, both of which are from Santa Barbara.

SPANISH FLAG (*Sebastichthys rubrivinctus* Jor. & Gilb.).—At Monterey this species is known by the very appropriate name of "Spanish Flag," from its broad bands of red, white, and red. It reaches a weight of about six pounds. It is found in very deep water on rocky reefs about Santa Barbara and Monterey. It is perhaps the least common in the markets of all the species, except *Sumbrosus*. In coloration it is the most brilliant fish on the coast.

RED ROCK-FISH (*Sebastichthys ruber* (Ayres) Lock.).—This species is usually the "Red Rock-fish" *par excellence*. At Monterey it is called by the Portuguese "Tambor," a name evidently transferred from some Atlantic species. It probably reaches a larger size than any other species, attaining a weight of twelve or more pounds. It ranges from Santa Barbara to Puget Sound, its abundance increasing to the northward. It lives in water of considerable depth. In the markets of San Francisco it is one of the most common species. Large specimens about Victoria, in the Straits of Fuca, had the skull above the brain infected by an encysted parasitic worm. Great numbers of them were seen in the Straits of Fuca, according to Mr. Swan, swimming stupidly near the surface, so torpid that the Indians killed them with clubs. According to the Indians, they had been struck by the Thunder-bird, which, with its companion, the Lightning-fish, causes many of the phenomena in that region. The smaller specimens of this species rank well as food-fishes; the larger ones are likely to be coarse or tough.

RASHER (*Sebastichthys miniatus* Jor. & Gilb.).—This species is known to the Portuguese at Monterey as the "Rasher," a name of unknown origin and orthography. It ranges from Santa Barbara to San Francisco, living in water of moderate depth. It is comparatively common, and is frequently seen in the markets, though in much less numbers than *S. ruber* and *S. pinniger*. In size and quality it agrees closely with *S. pinniger*.

ORANGE ROCK-FISH (*Sebastichthys pinniger* (Gill) Lock.).—This species is usually called simply "Red Rock-cod" or "Red Rock-fish" and not distinguished from the two preceding. The Portuguese at Monterey know it by the name "Fliaum," a word of unknown origin. It is one of the largest species, reaching a weight of eight or ten pounds. It ranges from Monterey to Puget Sound, being generally very abundant in deep water, where it is taken on trawl-lines. This is probably the most abundant of the larger species. At San Francisco individuals are often found with black discolored areas, looking like ink-blotches, on their sides. No cause for this has been noticed, and if it be a disease it does not seem to discommode the fish. In the market this species grades with *S. ruber*, and, like it, is often split and salted.

GREEN GARRUPA (*Sebastichthys atrovirens* Jor. & Gilb.).—This species is commonly known as "Garrupa" and "Green Rock-fish," being rarely distinguished from *S. rastrelliger*. It reaches a

weight of about three pounds. It ranges from San Diego to Monterey, being more southerly in its distribution than the other species. It lives in rocky places, in rather shallow water, and is generally common, especially south of Point Concepcion. It is considered excellent food.

REINA (*Sebastichthys elongatus* (Ayres) Gill).—This species is known as "Reina" (Queen) at Monterey. It is a small fish, reaching a weight of less than two pounds, and lives in deep water about Monterey and the Farallones. It is never very common in the markets, although frequently taken in considerable numbers.

RED ROCK-FISH OF ALASKA (*Sebastichthys proriger* Jor. & Gilb.).—In habits this species agrees with *S. elongatus*. It is usually still smaller, rarely weighing more than a pound. Its range extends northward to the Aleutian Islands, where it reaches a large size, and is of considerable importance as a food-fish.

VIUVA (*Sebastichthys ovalis* (Ayres) Lock.).—This species is known at Monterey as "Viuva" (Widow); the reason not evident. It reaches a weight of three or four pounds. It is found from Santa Barbara to Monterey, in deep water, and is seldom brought to market.

Sebastichthys entomelas Jor. & Gilb., is a species very similar to the preceding in size and habits. Thus far it has been only found in deep water outside of Monterey Bay.

BLACK ROCK-FISH (*Sebastichthys mystinus* Jor. & Gilb.).—This species, usually called the "Black Rock-fish," in Puget Sound is known, with its more abundant relative, *Sebastichthys melanops*, as the "Black Bass." The Portuguese at Monterey call it "Pesce Prêtre," or Priest-fish, in allusion to its dark colors, so different from those of most of the other members of the family. It reaches a weight of five pounds, but as usually seen in the markets varies from two to three. It ranges from Santa Barbara to Vancouver's Island, inhabiting water of moderate depths. It is much more abundant about Monterey and San Francisco than either northward or southward, and large numbers are taken in Tomales Bay. In the markets of San Francisco it is found, taking the year through, in greater numbers than any other species. It sells at a lower price than the others, its color causing a prejudice against it, although the quality of the flesh doubtless differs little from that of the rest.

ALASKA BLACK ROCK-FISH (*Sebastichthys ciliatus* (Tiles.) Jor. & Gilb.).—Specimens of this species from the Aleutian Islands are in the National Museum. Nothing distinctive is known in regard to its habits, which probably agree with those of *S. melanops*.

SPOTTED BLACK ROCK-FISH (*Sebastichthys melanops* (Grd.) Jor. & Gilb.).—This species is confounded with *S. mystinus* by the fishermen, under the name of "Black Bass" in Puget Sound, "Black Rock-fish" in San Francisco, and "Pesce Prêtre" at Monterey. In size and value it agrees with *S. mystinus*. Its range is more northerly, from Monterey to Puget Sound, being not very common at San Francisco, and one of the most abundant species in Puget Sound.

YELLOW-TAIL ROCK-FISH, (*Sebastichthys flavidus* (Ayres) Lock.).—This species is occasionally called the "Green Rock-fish" or "Rock-cod" at San Francisco. At Monterey it is always known by the appropriate name of "Yellow-tail," the caudal fin being always distinctly yellow. To distinguish it from the Yellow-tail of farther south we may call it the Yellow-tail Rock-fish. This species reaches a weight of six or seven pounds, but its usual weight is about two. It ranges from Santa Catalina Island to Cape Mendocino, and is taken both in deep water and near shore. About Monterey and San Francisco it is very abundant, and is one of the principal species in the markets. As a food-fish it is considered as one of the best in the group.

BOCCACCIO (*Sebastodes paucispinis* (Ayres) Gill).—About Monterey and San Francisco this species is known as "Boccaccio" or "Boccac'" (*bocatch*) to the Italians, and as "Mérou" (*mâroo*) to the Portuguese. American fishermen use the name "Jack," and those who fish for the young from

the wharves call them "Tom-cod." The name "Boccaccio" (Big-mouth) is very appropriate; "Mérou" is transferred from Atlantic species of *Epinephelus;* "Jack" comes from the species of *Esox* and *Stizostedium* which in the Southern States are called by that name. This species is one of the largest of the group, reaching a weight of twelve to fifteen pounds. Its average size in the markets is greater than that of any of the others. It ranges from the Santa Barbara Islands to Cape Mendocino. It inhabits reefs in deep water, only the young coming near the shore. It is rather more abundant southward than about San Francisco. It is, however, a common market-fish, and its flesh is considered excellent. It is probably the most voracious of the family.

Five species of the genus *Sebastichthys*, namely, *S. melanops*, *S. caurinus*, *S. maliger*, *S. proriger*, and *S. ciliatus*, attain to large size and considerable commercial importance in Alaska, and are discussed by Dr. Bean in his paper on the "SHORE FISHERIES OF ALASKA" in another section of this work. *S. melanops* is called "Black Bass" at Sitka.

85. THE ROCK TROUTS—CHIRIDÆ.

By DAVID S. JORDAN.

A family of fish of considerable importance on our Pacific coast is that of the *Chiridæ*, or Rock Trouts, no representatives of which are known in the Atlantic. One or two species of the family occur in the Sea of Japan.

BOREGATA (*Hexagrammus Stelleri* Tilesius).—This species is known in Puget Sound by the Italian name of "Boregata" or "Boregat'." The name "Starling" is applied to some fish, supposed by us to be this species, in the Straits of Fuca. It reaches a length of fifteen inches and a weight of three pounds. It ranges from Puget Sound to Kamtschatka. In Puget Sound it is comparatively abundant, living about rocks. It spawns in July. It feeds on crustaceans, worms, and fishes, and apparently gets its food on the bottom in deep water, as the animals taken from its stomach are often of a kind not seen near shore. Its intestines are very often full of long taenioid worms, supposed to be parasitic. As a food-fish, it ranks with the other Rock-trout, being of fair quality, but inferior to *Ophiodon* and *Sebastichthys*.

GREEN ROCK TROUT (*Hexagrammus lagocephalus* (Pallas) Jor. & Gilb.).—This species is confounded with others of this genus under the names of "Rock Trout," "Sea Trout," "Boregat'," and "Bodieron." At Cape Flattery this fish and the preceding receive the Indian name of "Tsebarqua." In size and value it corresponds very closely to the preceding. It ranges from Monterey to Kamtschatka, being nowhere very abundant, although not a rare fish. Its food is largely crustacean. Its flesh, like that of *Ophiodon*, is often colored green.

SPOTTED ROCK TROUT (*Hexagrammus decagrammus* (Pallas) Jor. & Gilb.).—The name "Boregata" is applied to this species by the Italians on Puget Sound. The name "Rock-cod" is also given to it. From San Francisco southward, the names "Rock Trout" and "Sea Trout" are common. The Portuguese at Monterey call it "Bodieron." It reaches a length of fifteen inches and a weight of two or three pounds. It ranges from San Luis Obispo to Alaska, and is much more generally common than any of the other species, and large numbers are brought into the market of San Francisco. It lives in rocky places at no great depth. It feeds voraciously on crustacea and worms. It spawns in July. It dies at once on being taken from the water, and the flesh becomes rigid and does not keep as well as that of the rock-fish. It is a food fish of fair quality, but not extra. The sexes are very unlike in color, and have been taken for distinct species.

CULTUS COD (*Ophiodon elongatus* Girard).—This species is universally called "Cod-fish" where the true cod is unknown. About Puget Sound the English call it "Ling." Among the

Americans the word "cod" is used with some distinctive adjective, as Cultus Cod ("cultus" meaning, in the Chinook jargon, *of little worth*), "Bastard Cod," "Buffalo Cod," etc. The name "Blue Cod" is also given to it from the color of its flesh. The name "Rock Cod" applied to other Chiroids and to Sebastichthys, and thence even transferred to *Serranus*, comes from an appreciation of their affinity to *Ophiodon*, and not from any supposed resemblance to the true codfish. The Cultus Cod reaches a length of five feet, and a weight of fifty or sixty pounds, the largest specimens being taken in northern waters. Many very small ones come into the San Francisco market, being taken in the sweep-nets of the paranzelle. These weigh less than a pound; the average of the large ones is from six to ten pounds. It ranges from Santa Barbara to Alaska, being very abundant everywhere north of Point Concepcion. It lives about rocky places, and sometimes in considerable depths, and spawns in summer. It feeds upon fishes and crustacea and is excessively voracious. It often swallows a red rock-fish when the latter is on the hook, and is thus taken. Like other large fishes, it is subject to the attacks of the hag-fish (*Polistotrema*). As a food-fish it holds a high rank, being considered rather superior to the rock-fish. From its great abundance, it is one of the most important fishes on the Pacific coast.

Zaniolepis latipinnis Girard.—This species ranges from San Francisco northward in deep water. It reaches a length of about a foot, and is of no economic value.

Oxylebius pictus Gill.—This bright-colored little fish ranges from Santa Barbara to Vancouver's Island, living among rocks near shore. It reaches a length of six inches, is rarely taken, and then used only for bait.

Myriolepis zonifer Lock.—The single specimen known was taken at Monterey.

BLACK CANDLE-FISH (*Anoplopoma fimbria* (Pallas) Gill).—This species is known in Puget Sound by the name of "Horse-mackerel." At San Francisco it is usually called "Candle-fish." In the markets it is sometimes fraudulently sold as Spanish mackerel. It reaches a length of twenty inches and a weight of five pounds. It ranges from Monterey northward to Sitka, in rather deep water, and is generally common, especially northward. At Seattle it is one of the most abundant fishes, but in the San Francisco market it is seldom seen in large numbers. It feeds on crustaceans, worms, and small fishes. As a food-fish it is held in low esteem, the flesh being rather tough and tasteless.

In the Straits of Fuca it reaches a much larger size than has been noticed elsewhere. It is here very highly valued by the Indians, according to Mr. Swan. It is called by the Indians "Beshow."

In Alaska, according to Dr. Bean, the most important chiroid fishes are *Ophiodon elongatus*, *Anoplopoma fimbria*, *Hexagrammus decagrammus*, *H. lagocephalus*, *H. ordinatus*, *H. asper*, and the "Yellow Fish," "Striped Fish," or "Atka Mackerel," *Pleurogrammus monopterygius* (Pallas) Gill, which is the chief of them all. This fish is most abundant about the Aleutian chain and the Shumagins, its northern limit as now understood being about Kodiak, and its western limit at Attu. It congregates in immense schools, and can be taken in purse-seines like the mackerel, which it strongly resembles in taste after being salted in the same manner.

86. THE TAUTOG OR BLACK-FISH—TAUTOGA ONITIS.

NAMES.—One of the best known shore species of the Atlantic coast is the Tautog or Black-fish. This fish is now found in greater or less abundance from Saint John, New Brunswick, to Charleston, South Carolina. East of New York it is usually called Tautog, a name of Indian origin, which first occurs in Roger Williams' "Key to American Language," printed in 1643, in which this fish is enumerated among the edible species of Southern New England. "Tautauog" would consequently seem to be a word from the dialect of the Narragansett Indians. On the coast of New

York it is called "Black-fish"; in New Jersey also "Black-fish" and "Smooth Black-fish," "Tautog," or "Chub"; on the eastern shore of Virginia "Moll," or "Will George"; at the mouth of the Chesapeake "Salt-water Chub," and in North Carolina the "Oyster-fish." Of all these names Tautog is by far the most desirable for general use. There are several other species along our coast called Black-fish, especially the sea-bass, which is often associated with the Tautog. The names Oyster-fish and Chub are also pre-engaged by other species.

DISTRIBUTION.—Though the present geographical distribution of the Tautog is well understood, there is reason to believe that its range has been very considerably extended in the present century by the agency of man. That this species was known in Rhode Island two hundred and thirty years ago is reasonably certain from the reference by Roger Williams, already referred to, and in 1776 it was stated by Schoepf that it was very abundant in summer at New York. It is in greatest abundance between the southern angle of Cape Cod and the Capes of Delaware, which would indicate that within these limits, at least, the species has always existed. The waters of Long Island Sound and those immediately adjoining seem especially well adapted for its residence.

Mitchill, writing in 1814, remarked: "The Tautog was not originally known in Massachusetts Bay; but within a few years he has been carried beyond Cape Cod, and has multiplied so abundantly that the Boston market has now a full supply without the necessity of importing from Newport and Providence." This statement is confirmed in a way by Mr. Isaac Hinckley, of Philadelphia, who tells me that in 1824 he saw several individuals from Cohasset Rocks, Jerusalem Road, Massachusetts, and that the fish was at that time said by the fishermen to be entirely new to them. Storer, writing about 1867, remarked: "Although a few years only have passed since this species was brought into Massachusetts Bay, it is now taken along a large portion of the coast. At Plymouth, Nahant, and Lynn, at some seasons, it is found in considerable numbers, and is frequently caught from the bridges leading from Boston. The Boston market is for the most part supplied by Plymouth and Wellfleet." As early as 1851 they had spread northward to the Bay of Fundy, and in that year it is stated that many were sold in the fish market at Saint John, the largest of which weighed eight pounds: Mr. Lanman wrote that he obtained there in July and August specimens nineteen inches long and weighing four pounds.

The rocky shores of Cape Ann seem particularly well adapted to its peculiar habits, and large numbers are annually obtained from the rocks. So long has it been acclimated and so well known is it, that the local authorities of that region are inclined to doubt that it is not native. The "Gloucester Telegraph" of May 5, 1860, challenged the statement that the Tautog was a new fish, declaring that many years ago they were very plenty, and that after a period of scarcity they reappeared. So abundant had they become in 1836 in the harbor of Wellfleet, Massachusetts, that three Connecticut smacks were accustomed summer after summer to devote their entire energies to their capture in this locality, and this fishery has continued up to the present day. In sandy localities, like the harbor of Provincetown, they have never secured a firm hold, though large specimens are sometimes taken under the wharves.

As to the extension of the range of this species southward we have the statement of Holbrook, quoted by DeKay, writing in 1842: "Attempts have been made to introduce this fish farther south, but with limited success. I am informed by my friend, Dr. Holbrook, that General Thomas Pinckney imported from Rhode Island a smack load of the Tautog and set them adrift in the harbor of Charleston, South Carolina, where they are to be found to this day. They are still occasionally caught, weighing from one to two pounds, but never in such quantities as to be brought to market." Mr. Earll obtained specimens at Charleston in January, 1880. Certain ich-

thyologists, among whom is Professor Jordan, express skepticism as to the range having been thus artificially extended southward.

At Cape Lookout, North Carolina, Jordan records the species, under the name "Oyster-fish," as rather common, the young abundant about the wharves. About Norfolk and in the mouth of Chesapeake Bay they occur, and also on the coast of Southern New Jersey, where they are taken in the vicinity of Beasley's Point, in the channel ways and along the shores, and they are said to be somewhat common on the banks off Sandy Hook and in the southern bays of Long Island. These sandy regions, however, are not so much frequented by them as those abounding in rocky beaches and ledges.

HABITS.—Although the Tautog appears to thrive in cool water, as has been shown by the rapid extension of the northern range, they seek refuge from too great cold by retreating in winter to somewhat deeper water than that preferred in summer. Here they appear to take refuge under the stones and in crevices of the rocks, if we may judge from their habits as observed in aquaria, their smooth, slimy skins, with scales protected from abrasion by a thick epidermis, enabling them to move about among the sharp-pointed rocks unharmed. They are on this account also especially well suited for confinement in the wells of smacks and in "live-cars," where it is customary to keep them living until required for market. They appear to enter upon an actual state of hibernation, ceasing to feed and the vital functions partially suspended. It is the opinion of fishermen that during the hibernating season the vent becomes entirely closed up, as is known to be the case with hibernating mammals. It is certain that they do not retreat far from the shore in winter, and that very cold weather, especially in connection with a run of low tides, often causes very remarkable fatalities. There are instances of their death in immense numbers. In February, 1857, after a very cold season, hundreds of tons drifted upon the beach at Block Island, and along the southern shores of Massachusetts and Rhode Island, and a similar catastrophe took place in 1841. In March, 1875, it is stated that as much as a ton was thrown ashore in the drift ice at Cuttyhunk. They were seen floating by the Hen and Chickens light-ship for three successive days. In Southern New England they become torpid in November and December. It is stated that they are sometimes caught as late as Christmas. It is probable that many do not enter upon a state of complete torpidity, but remain in a partially active state in deep holes not far from the shore, and that it is these, rather than the hibernating individuals, which are especially liable to injury from the cold. A few are taken in Rhode Island in midwinter both by line and in lobster-pots. North of Cape Cod they are rarely taken except in summer,[1] while towards the southern limit of their range they are apparently as abundant in winter as at any other time. Mr. Nathan King, a Rhode Island fisherman, states that when the sun is very hot the Tautog leaves the clear spots for shelter among the weeds and rocks.

FOOD.—As might be inferred from its haunts and from the character of its strong, sharp teeth, the food of this fish consists of the hard-shelled mollusks and crustaceans which are so abundant among the rocks. In their stomachs have been found, among other things, lobsters, crabs of various species, clams, mollusks, squids, scallops, barnacles, and sand-dollars. Many of the smaller mollusks they swallow, shells and all, ejecting the hard parts after the flesh has been digested. The common bait for Tautog in the spring is the clam, preferably the soft clam, for at this time the fishermen say they have tender mouths. In the fall crabs and lobsters are used, the fiddler-crab and rock-crab being the favorites. They are sometimes taken with a bait of marine worms.

REPRODUCTION.—In Narragansett Bay and vicinity they spawn from the end of April until August.

[1] The first of the season were taken at Gloucester May 13, 1881.

The pound fishermen find them to be full of ripe eggs when they begin to approach the shore in early summer. Mr. Christopher E. Dyer, of New Bedford, has witnessed the operation of spawning in Buzzard's Bay in the middle of June, in water about two fathoms deep. This was in 1859 or 1860, about two miles east of Seconnet Point. The number of eggs has not yet been determined, nor is it known how long the period of incubation continues, but young fish are found abundantly in the eel-grass along the shore in August and September, and have been observed at various points from Cape Lookout to Monomoy. There can be no question, however, that there are breeding grounds near Charleston, South Carolina, and north to Cape Cod, since the species is very local in its habits and does not make long journeys to select spawning beds. Little is known of their rate of growth, though it is probably slow. Capt. Benjamin Edwards, of Wood's Holl, Massachusetts, kept thousands of small Tautog confined in a pond for five years, and at the end of that time, when six years old, none weighed more than two and one-half pounds. A half-pound fish which he confined in a lobster-car, with plenty of room and plenty of food, increased from one-half to three-quarters of a pound in six months. The average weight of those sent to market does not exceed two or three pounds, though individuals weighing ten, twelve, and fourteen pounds are by no means unusual. The largest on record was obtained near New York in July, 1876, and is preserved in the National Museum—its length thirty-six and one-half inches, its weight twenty-two and one-half pounds.

ABUNDANCE.—The abundance of this species past and present has been actively discussed and much interesting testimony on the subject may be found in the report of the United States Commissioner of Fisheries. This was one of the fish regarding which the claim was made that it has been almost exterminated in Rhode Island by overfishing: upon this point, however, the opinions of fishermen and experts are much at variance. In 1870 when, according to general opinion, Tautog had been almost exterminated in the waters of Narragansett Bay, the records of Newport fish-markets show that in one day, November 2, eleven men caught about 3,000 pounds of Tautog with hook and line, besides cod and other fish, while on the following day the catch of fifteen men was 28,000 pounds, besides codfish caught to the amount of 600 pounds, being an average of over 2,600 pounds to each man. These catches compare very favorably with that recorded at Fir Rock Ledge, Wareham, ten years previous, when, on the 9th of October, two men caught, in three hours, 271 pounds of Tautog, a catch which was pronounced by local authorities the greatest ever made in those waters.[1] Colonel Lyman, Massachusetts commissioner, writing in 1872, remarked: "Great complaint is made of the scarcity of this valued species north and south of Cape Cod, but especially near the mouth of Narragansett Bay, where they are said to be not more than one-eighth as numerous as they were a score of years ago." Although much testimony has been printed in the reports of the Fish Commission of the United States and of Rhode Island, the general tendency of which is to show that old fishermen believe that Tautog and other fish are much less abundant than in the days of their youth, nothing definite has yet been proved.

The Tautog has always been a favorite table fish, especially in New York, its flesh being white, dry, and of a delicate flavor. Storer states that they are frequently pickled, and may be kept in weak brine for a long time, and in this state they are considered by epicures a delicacy.

THE TAUTOG OR BLACK-FISH FISHERY.—The capture of Tautog is chiefly accomplished by the line fishermen of Southern Massachusetts and Rhode Island, and the weir fishermen of the same district. No one fishes for Tautog alone, and it is consequently more difficult to estimate the

[1] Barnstable Patriot, October 9, 1860.

quantity annually taken. About 200,000 pounds were brought to the New York market last year. Local consumption is considerable, and the total amount annually taken may be estimated at from 400,000 to 450,000 pounds. At least two hundred fishermen are entirely or partly engaged in this business between Cape Cod and New York. The catch of such fishermen in Narragansett Bay is estimated at 6,000 pounds each annually. This gives in round numbers 100,000 pounds taken by hook and line along this stretch of coast. To this should be added 20,000 pounds estimated to be taken on the coast of New Jersey and southward, and 20,000 more north of Cape Cod. Tautog are also frequently taken in the weirs and pounds, and the catch of these for the year 1876 was estimated as is shown in the following table:

	Pounds.
Weirs on north side of Cape Cod	2,274
Weirs on south side of Cape Cod	561
Weirs in Vineyard Sound	29,220
Weirs in Buzzard's Bay	39,423
Weirs in Narragansett Bay	156,750
Weirs on Block Island	33,153
Weirs in Fisher's Island Sound	14,000
Weirs on eastern end of Long Island	36,000
	311,381

At Noank, Connecticut, there is in the fall a season of "black-fishing" which continues from the middle of October until the snow begins to fall, about the first of December. About twenty-five men are engaged in this fishery during the season specified, some of whom begin a month or two earlier. They fish in Fisher's Island Sound at a depth of six to eight fathoms, using crabs and lobsters for bait. The average catch of each man for the season is estimated by Captain Ashby at one thousand pounds. The most northerly point where there is a regular fishery for them is, as has already been mentioned, in Wellfleet harbor. According to DeKay, three smacks were constantly employed from April to November. These smacks doubtless, then as now, hailed from Connecticut. In 1879 these vessels were still upon the old ground, one of them hailing from Westport and one or two from New London. One of the skippers was said to have fished upon this ground every season for thirty years. I was told in Wellfleet that they ordinarily remained about three weeks to fill their wells, obtaining in that time from two to four thousand pounds.

Angling for Tautog from rocks is a favorite pursuit of amateur fishermen all along the coast, particularly about New York, where there are precipitous shores, the anglers standing upon the rocks. July 12, 1879, Capt. S. J. Martin caught in this way, at Eastern Point, Gloucester, seven, two of which weighed twenty-one and a half pounds. In Long Island Sound and other protected waters they are usually fished for from a boat anchored among the reefs or near wrecked vessels. Mitchill, writing in 1814, describes the methods of this fishery better than any other subsequent authority: "Rocky shores and bottoms are the haunts of Blackfish. Long experience is required to find all these places of resort. Nice observations on the landmarks in different directions are requisite to enable a fishing party to anchor on the proper spot. For example, when a certain rock and tree range one way, with a barn window appearing over a headland the other way, the boat lying at the point where two such lines intersect each other, is exactly over some famous rendezvous. . . . At some places Black-fish bite best upon the flood. In others they are voracious during the ebb. Thunder accompanying a shower is an indication that no more of them can be caught. The appearance of a porpoise infallibly puts an end to the sport. Dull weather with an easterly wind is generally the omen of ill luck. . . . Some persons who live contiguous to

the shores where are situated the rocks which are frequented by Tautog invite the fish there by baiting. By this is meant the throwing overboard broken clams or crabs to induce the Black-fish to renew their visits; and fine sport is procured."

As has been already stated, the Tautog on the coasts of the United States is extremely sensitive to cold, and at the approach of the time of hibernation the vent becomes sealed, the fish thus becoming prepared for a minimum consumption of its own fat during its winter sleep.

The subjoined notice of the torpidity of the Tautog and the Scup by Captain Atwood will be found on page 212 of the Report of the United States Commissioner of Fish and Fisheries for 1871–'72.[1]

87. THE CHOGSET OR CUNNER—CTENOLABRUS ADSPERSUS.

The Chogset or Cunner, *Ctenolabrus adspersus*, is very similar in appearance to the Tautog, though much smaller and far less important. Its range is more northerly. I can find no record of its occurrence south of New York. DeKay remarks: "I am not aware that it is found south of Delaware Bay." From New York to the Straits of Canso the species is exceedingly abundant, being found everywhere in harbors and bays, particularly in the vicinity of fish-houses where offal is thrown overboard. Cuvier had specimens from Newfoundland, but it abounds on the coast of Labrador. It is closely related to the "Goldsinny," *Ctenolabrus rupestris*, and the "Connor" or "Gilt-head," *Crenilabrus melops*, of Great Britain and adjoining Europe. It has numerous common names. In Southern New England it is called "Chogset," a name of Indian origin, sometimes pronounced Cachogset. This name appears to have been in occasional use as far west as New York, where, in Mitchill's time, it was also called "Bluefish." In Maine, the British Provinces, and in some parts of Massachusetts the name "Cunner" is in use, evidently having been brought over by the English colonists who remembered a very similar fish at home which has this name. In New York, in revolutionary times, the name "Burgall" was in use, and continued in use at least until 1854, when it is stated by Gill to have been the accepted name in the New York market. This name also is of English origin, certain species of this family being called "Bergylt" in parts of England. This name appears to hold in Eastern Long Island at the present time. At Provincetown they are called "Sea-perch," and at the Isle of Shoals and occasionally on the adjoining mainland "Blue-perch" and "Perch," this also being a reminiscence of English usage. At Salem they are called "Nippers," and occasionally here and elsewhere "Bait-stealers." Where Cunners are found at all they are exceedingly abundant, and, though performing a useful duty as scavengers, are a pest of fishermen, from their habit of nibbling the bait from their hooks. They are the especial detestation of those who fish for tautog, since the two species are ordinarily found together. Their

[1] In Brown's "American Angler's Guide," in the article on Tautog or Black-fish, it is remarked: "The Black-fish abounds in the vicinity of Long Island, and is a stationary inhabitant of the salt water. He may be kept for a long time in ponds or cars, and even fatted there. When the cold of winter benumbs him he refuses to eat any more, and a membrane is observed to form over the vent and close it. He begins to regain appetite with the return of warmth in the spring." (P. 178.)

"Now we know that Tautog hibernate among rocks near the coast and in our rivers, and it has been stated by Mr. L. Tallman or Mr. Daniel Church that some years ago, after a very cold snap, not only many Tautog were washed ashore frozen stiff, but afterward quantities were also found dead among rocks off the coast. If, during the winter, they don't feed as stated above, and this membrane closes them up, the conclusion must be that they remain in a state of torpor or sleep during cold weather. Now it happens that the scup, when first taken by traps, are in a state of torpor; they neither eat nor have any passage. It is probably sealed up like the Tautog, and nothing in the shape of food is to be found within them. Some say they are blind, and they seem hardly able or willing to move.

"The inference, then, is, that the scup have also been hibernating within a short distance from the coast, in the same state as the Tautog. This would account for the stray scup mentioned by Mr. Southwick as having been occasionally found in March. A warm day wakes him up, and he visits the shore for a day or so and then returns. To my mind this is a more reasonable way of accounting for his presence than to assume that he has been left behind. If these facts are as stated, it is to be presumed that scup are a local fish, and do not leave their localities any more than Tautog, about the propriety of the classification of which as a local fish there is no question."—ATWOOD.

food is very similar to that of the tautog, except that they cannot swallow large shells. They feed also upon dead animal matter, and are among the most important scavengers of our harbors. Numbers of them may be taken by lowering a net containing a piece of meat or fish and quickly raising it to the surface. Like the tautog, Cunners are local in their habits, only moving from the shoal water in extreme cold weather, and, though adapted for living in colder water, rarely retreat except in the severest weather. In winter, however, they rarely are caught with the hook. The first of the season of 1881 at Gloucester were caught May 8. A very cold season sometimes destroys them. It is recorded that in January, 1835, great quantities were frozen and thrown up on the shore between Gloucester and Marblehead.[1] In June and July they spawn on their feeding grounds in Southern New England, and in July and August young fish three-quarters of an inch or more are taken abundantly along the shores. They appear to become adult and to breed when three inches long. The largest I have observed was taken at Wood's Holl, in July, 1875: its weight was twelve ounces, its length ten and a half inches, and it was spawning freely. Storer claims to have seen them fourteen inches long, and I am assured that they sometimes attain a weight of two pounds. From Eastport, Maine, to the vicinity of Boston, the Cunner is a favorite article of food. Elsewhere it is rarely eaten and is usually regarded with disgust—a foolish prejudice, for it is one of the most agreeably flavored small fishes on our coast. Immense quantities are taken with the hook from the rocks, bridges, and boats, especially in the vicinity of cities like Boston and Portland. They are also taken in immense quantities in nets. The Irish market-boats of Boston make a special business of catching them, using circular nets three or four feet in diameter which are baited and set among the rocks. Dr. Storer records that on the occasion of his visit to Labrador, in 1849, he found them so plentiful in the Gut of Canso that, by sinking a basket with a salt fish tied therein for bait, he continually caught them by the score, and by putting a few hundreds in the well of his sloop kept the crew well supplied with fish while at sea on the way to Labrador. The people of Nova Scotia, like those south of Cape Cod, rarely, if ever, eat the Cunner. Mr. J. Matthew Jones informs me that in the summer of 1863, when the French fleet was anchored in Halifax Harbor, the sailors caught them for food in great numbers. About Saint Margaret's Bay, according to Mr. Ambrose, they are given as food to pigs: since, however, the pork of these fish-fed pigs always tastes oily, they are generally fed on some other food for a short time before being killed, and well dosed with sulphur. It was formerly customary in Boston to keep these fish alive for market in large cars, described by Storer as three feet deep, twelve to fifteen feet long, closed beneath and latticed at the sides, and anchored in deep water. Storer states that sometimes as many as five thousand fish were kept in a single car, and that these cars were replenished every week or fortnight. It is impossible to estimate with any degree of accuracy the quantity of Cunners annually taken. The catch of the Irish market-boats of Boston cannot fall much short of 300,000 pounds, and that of the other towns and States on the coast of New England is certain to be from 200,000 to 250,000 pounds.

88. THE PARROT-FISHES AND SOME OF THEIR ALLIES.

Several of the Parrot-fishes occur on the Florida coast, notably the Blue Parrot-fish, *Platyglossus radiatus* (Linn.) Goode, sometimes, according to Jordan, seen in Key West market, and *P. bivittatus*, known in Bermuda as "Slippery Dick," recorded by Jordan from Charleston market. They are gorgeous in color, but the flesh is so dry that they are held in slight esteem for table use.

[1] Gloucester Telegraph, January 14, 1835.

The Red-fish, of California.

This species, *Trochocopus pulcher*, writes Jordan, is everywhere known as the "Red-fish": the name "Fat-head" is occasionally used, and it is very rarely called "Sheepshead." It reaches a weight of twelve to fifteen pounds. It is found from Point Concepcion southward to Cerros Island in enormous numbers in the kelp. It is taken chiefly with hook and line. It feeds on crustaceans and mollusks. It is taken chiefly by the Chinese, who salt and dry it. It forms half of the total catch of the Chinese south of Point Concepcion. It does not rank high as a food-fish, its flesh being coarse. The fat forehead is said to make excellent chowder.

The Señorita-fish, of California.

At Monterey, California, this species, *Pseudojulis modestus*, is known as, "Pescerey"; southward it is called "Señorita." It reaches a weight of less than half a pound. It is found in the kelp from Monterey southward to Cerros Island, and is generally common. It feeds chiefly on crustacea. It is used chiefly for bait, although the flesh is said to be of excellent quality.

The Kelp-fish, of California.

This species, *Platyglossus semicinctus*, bears in company with *Heterostichus rostratus*, and perhaps others, the name of "Kelp-fish." It reaches a pound weight, and a length of nearly a foot. It is found in the kelp about Santa Catalina Island and southward, and is not very abundant. It feeds on crustacea, and spawns in July. Its flesh is said to be of good quality.

The Hog-fish—Lachnolæmus falcatus.

This fish is, according to Mr. Stearns, abundant at Key West and among the Florida coral reefs, although he has not observed it north of the Gulf of Mexico. It there attains a considerable size, and a weight of twelve or fifteen pounds, although the average size is not more than one-fourth that size. In the Key West market it appears almost daily, and is much esteemed for food. This species occurs throughout the West Indies, and is one of the favorite food-fish of Cuba, although its sale is forbidden by law, on account of the supposed poisonous nature of its flesh. In the Bermudas it is one of the most important of the food-fish, attaining sometimes the weight of twenty pounds. It is caught by line-fishermen among the reefs, at a depth of five to forty fathoms. Like the other members of this family, it feeds upon small fish and upon bottom crustaceans and mollusks. Its brilliant red color renders it a conspicuous object in the markets. During the different stages of growth its species undergoes many changes of form, and has been described under several different names. The large adult male is remarkable on account of a heavy black blotch over the forehead and over the eyes. The name "Hog-fish" refers to the swine-like appearance of the head, jaws, and teeth. At the entrance to the Great Sound, in Bermuda, is a reef called Hog-fish Shoal, which is surmounted by a beacon bearing an enormous effigy of a Hog-fish in metal.

89. THE DEMOISELLE AND THE CICHLID FAMILIES.

Among the reefs of Florida two or three species of the family *Pomacentridæ* are abundant. Most prominent among these is the "Sergeant Major," *Glyphidodon saxatilis* (L.) C. & V., called in Bermuda the "Cow-pilot," from an alleged habit of being always found in the society of the "Cow-fish," or *Ostracion*. This fish sometimes attains the length of ten inches and the weight of a pound or so, but is usually of a smaller size and is not highly esteemed for food. It is found throughout the tropical waters of the entire world.

There are several smaller species of this and of allied genera in the Gulf of Mexico, and on the western side of the Isthmus of Panama and in the Gulf of California. On the California coast occurs a species, *Pomacentrus rubicundus*, conspicuous by reason of its uniformly deep crimson or orange coloration, which is usually known as the "Garibaldi" among the Italians. The names "Gold-fish" and "Red Perch" are also used, all of them referring to its brilliant orange colorations. It reaches a weight of three pounds, and a length of less than a foot. It is found about the Santa Barbara Islands and southward to Lower California. It lives about rocky places, and is generally abundant. Its food is largely crustaceous. It is a food-fish of low grade, and has little economic importance. Another somewhat noteworthy species is known in California, on account of its dusky colors, as the "Blacksmith," *Chromis punctipinnis*, Cooper.

"This fish," writes Jordan, "is known as the 'Blacksmith' from its dusky colors. It reaches a weight of about two pounds. It ranges from the Santa Barbara Islands southward, living about reefs of rock, and is locally abundant. It feeds on shells and crustacea. It is considered as indifferent food."

The family *Cichlidæ* is large, and is composed chiefly of fresh-water fishes occurring in the tropical parts of Africa and America. Among its members is a South American species, *Geophagus surinamensis*, which is often mentioned by writers on the instincts of animals on account of a peculiar habit of the males which carry in their mouths the eggs until they are hatched, and which are even said to allow the young fish to seek refuge within their jaws. We have no representatives of the family on our Atlantic coast, though one or two species of the genus *Heros* occur in the brackish waters of Texas.

90. THE SURF-FISH FAMILY—EMBIOTOCIDÆ.

By DAVID S. JORDAN.

This remarkable group of fishes forms the most characteristic feature of the fauna of our Pacific coast. Of the nineteen species now known, all but one (*Ditrema Temmincki* of Japan) occur on the coast of California, and most of them in very great abundance. The species are most of them very similar in habits and economic value, and the following general remarks are proffered before proceeding to the discussion of the different species.

NAMES.—The general name "Perch" is applied to these fishes everywhere along the coast. This unfortunate misnomer came about from their resemblance to the sun-fishes or "perch" of the Southern States, and to the "white perch," *Roccus americanus*, of the East. On the coast of Oregon the large species (especially *Damalichthys argyrosomus*) are called "Pogy" or "Porgee," in allusion to their undoubted resemblance to the scup or porgee of the East. The names "Minny," "Sparada," and "Moharra" are also applied to the smaller species northward. About San Francisco, the name "Perch" is given to them all, as well as to *Archoplites interruptus*, and separate names for the different species are seldom heard. From Monterey southward, the name "Surf-fish" is in common use, although the name "Perch" is still more common.

HABITS, &C.—The largest *Rhacochilus toxotes*, reaches a weight of four pounds; the smallest, *Abeona minima*, a length of four or five inches. So far as we are able to judge, the growth of the young is quite rapid, as the specimens are about half grown the first winter, and probably reach full size in two and a half to three years—perhaps, in some cases, in the second year.

The center of distribution of this group is from Santa Barbara to Tomales Bay. Northward the number of species decreases, while the number of individuals is, perhaps, equally great as far as the Gulf of Georgia. Southward both individuals and species rapidly diminish in number.

Their range probably extends from Cerros Island to Sitka; certainly no farther. Most of them live in shallow water, on a sandy bottom, both in the open sea and in sheltered bays. A seine drawn in the surf will often be filled with the silvery species (*Amphistichus: Holconotus*), and a seine drawn in a bay may be equally full of *Ditrema laterale*, *Ditrema Jacksoni*, etc. One species is confined to the fresh waters. Nearly all of them feed chiefly on crustacea, together with such small fish as they can swallow. The species of *Abeona* are chiefly herbivorous, feeding on seaweed.

The Embiotocoids are all oviparous. The young are fifteen to twenty in number, and are brought forth in summer: when born, the little fish are from three-fourths of an inch to two and a half inches in length, according to the species. They are closely packed together in the uterus, the inner surface of which forms folds partly separating the young from each other. The young are at first excessively compressed, with the soft parts of the vertical fins excessively elevated. As their development proceeds they resemble more and more the parent, and when born their form is quite similar, the body, however, more compressed, the fins higher, and the color usually red.

Impregnation probably takes place in the fall. In January most of the species have the young half grown as to length, and when the parent fish is caught the young readily slip out from the ovary. From January to June the fish-stalls where these fishes are sold are littered with these fœtal fish. Little is known of the place of spawning, but I suppose that the young are simply extruded in the water just outside the breakers and left to shift for themselves. As to the mode of impregnation, we have made no observations. Dr. Blake thinks that the fleshy thickening on the anal fin of the male is to give the female something to hold to with the ventral fins, and that the two sexes approach each other, ventral surfaces together, and with their heads in opposite directions. They have no special enemies except the larger predatory fishes and the fishermen, who destroy great numbers at the breeding time. No diseases have been noticed.

The species are all, with the exception of two or three of the smallest, used as food. Their flesh is watery, flavorless, and much inferior to that of the Scorpænoid, Sciænoid, and Percoid fishes, and only their abundance gives them value. Great quantities of them are consumed by the Chinese.

ALFIONE *Rhacochilus toxotes* Agassiz).—This species is called "Alfione" at Soquel, "Sprat" at Santa Cruz; elsewhere it is simply "Perch." It reaches a length of eighteen inches and a weight of five pounds, being much the largest of the group. It ranges from San Pedro to Cape Mendocino, and is generally common, although not nearly so abundant as some of the others. As a food-fish it is considered the best of this very indifferent group.

PORGEE (*Damalichthys argyrosomus* (Girard) J. & G.).—On the coast of Oregon and Washington this species is known as "Porgee"; elsewhere simply as "Perch," or "White Perch." It reaches a weight of two and a half pounds. It ranges from San Pedro to Vancouver's Island, its abundance steadily increasing to the northward so far as traced. At San Francisco it is rather common, but south of Point Concepcion rather rare. As a food-fish it ranks next to the preceding.

WHITE PERCH (*Ditrema furcatum* (Grd.) Günther).—This species occasionally reaches a weight of a pound, but is usually smaller. It ranges from Cape Mendocino to the Mexican line, being everywhere exceedingly abundant. It lives in sheltered bays. It is always present in the markets and is held in low esteem.

Ditrema atripes Jor. & Gilb.—This species reaches a weight of one and a half pounds. It has been noticed only in the Bay of Monterey, where it is generally rather common, being taken in seines near the shore.

BLUE SURF-FISH (*Ditrema laterale* (Agassiz) Günther).—This species is known as the "Blue Perch" or "Surf-fish." It reaches a weight of about two and a half pounds. It ranges from Santa

Barbara to Vancouver's Island, and is everywhere abundant. North of San Francisco it is the most common of the larger species. It is an important food-fish, although not of very good quality.

BLACK SURF-FISH (*Ditrema Jacksoni* (Agassiz) Günther).—This species is known as "Perch," "Surf-fish," "Black Perch," etc. About San Diego it is called "Croaker," which name, however, belongs properly to the Sciænoid fishes. It reaches a weight of two pounds. It ranges from San Diego to Puget Sound. North of Cape Mendocino it is scarce. From San Francisco southward it is probably brought into the market in greater numbers than any other species. It is but an indifferent food-fish.

Hypsurus Caryi (L. Agass.) A. Agass.—This species is known as "Moharra" to the Portuguese at Monterey; elsewhere it is a "Perch." It reaches the weight of a pound. It ranges from Tomales Bay to Santa Barbara, and is rather common, being sometimes taken in great numbers in spring. It is used chiefly as bait for rock-fish, the larger individuals only being sent to market. It is the most brightly colored of its family.

SILVER SURF-FISH (*Amphistichus argenteus* Agassiz).—This species is known as "Surf-fish" and "White Perch." It reaches a weight of three pounds. It ranges from Tomales to San Diego, and is locally often very abundant, especially along sandy beaches.

ROSY SURF-FISH (*Holconotus rhodoterus* Agassiz).—This species has no distinctive name with the fishermen. It reaches a weight of one and a half pounds. It ranges from Cape Mendocino to Santa Barbara, being often locally abundant, especially at Soquel, but it is not one of the more common species.

Holconotus Agassizi (Gill) Jor. & Gilb.—This species reaches a weight of but half a pound. In distribution and abundance it agrees with the preceding.

WALL-EYE SURF-FISH (*Holconotus argenteus* (Gibb.) Jor. & Gilb.).—This species is usually known as the "Wall-eye," in allusion to the great size of its eyes. It reaches a weight of half a pound. It ranges from Cape Mendocino to the Mexican line, and is generally abundant, especially in the surf. It is taken in large quantities, and is little esteemed.

Holconotus analis (A. Agass.) Jor. & Gilb.—This species reaches a weight of a quarter of a pound. It is found from San Luis Obispo to San Francisco. It is only locally abundant, and is not purposely sent to market. At Soquel, where it is abundant, it is used for bait.

Brachyistius rosaceus Jor. & Gilb.—This species weighs less than half a pound. It has been taken only in deep water off Point Reyes.

Brachyistius frenatus Gill.—This species rarely weighs more than a quarter of a pound. It ranges from Catalina Island to Vancouver's Island, living in water of moderate depth, and is locally exceedingly abundant, as at Monterey, Point Reyes, etc. It comes into the market only by accident, and is used chiefly for bait.

SPARADA (*Cymatogaster aggregatus* Gibb.).—This fish is usually known as the "Shiner." On Puget Sound the Americans call it "Minny," and the Italians "Sparad" or "Sparada." It is found from Vancouver's Island to the Mexican line, everywhere in great numbers, and is perhaps the most abundant species on the coast. It is rarely used except for bait.

Abeona aurora Jor. & Gilb.—This species reaches a weight of nearly half a pound. It is abundant in rocky places from Monterey to San Francisco, often frequenting rock-pools. It feeds on plants, and is occasionally sent to market.

SHINER (*Abeona minima* [Gibbons] Gill.).—This little fish is usually known as the "Shiner." It is the smallest of the group, rarely weighing a quarter of a pound. It ranges from Tomales Bay to San Diego, and is generally common, although not one of the most abundant species. Its appearance in the market is accidental.

"RIVER PERCH" (*Hysterocarpus Traski*, Gibbons).—This species very often reaches the weight of about half a pound. It is confined to the fresh water, being found in the Sacramento and San Joaquin Rivers, and other streams as far southward at least as San Luis Obispo. It is sent in small numbers to the markets of San Francisco, and is chiefly eaten by the Chinese.

91. THE MOHARRA FAMILY—GERRIDÆ.

This family is represented on our eastern coast by four species, all of which are very small and of little consequence except as food for larger fishes.

Gerres argenteus, first discovered by Professor Baird at Beesley's Point, New Jersey, appears to be common from North Carolina to New Jersey, and has been, within two or three years, observed at Wood's Holl, Massachusetts.

G. harengulus and *G. homonymus* occur in the Gulf of Mexico. In the Bermudas there are three species of this genus; these are known by the names "Shad" and "Long-boned Shad." They are seined in great numbers, and constitute an important article of food.

92. THE THREAD-FISH FAMILY—POLYNEMIDÆ.

The family *Polynemidæ* is remarkable by reason of the elongate filaments which are developed in connection with the pectoral fin. Günther has remarked: "Their eyes are large, but generally obscured by a filmy skin, so that these feelers must be of great use to them in helping them to find their way to their food. It is evident, from the organization of these fishes, that they live in thick water or muddy bottoms, such as are found near the mouths of great rivers."

There are two or three species upon our coast, one of which, the "Thread-fish" of Pensacola, *Polynemus octonemus*, is the subject of the following interesting observations by Mr. Stearns:

"The Thread-fish is rather common at Pensacola in summer, and has not been observed elsewhere in the Gulf by me. My first specimen was taken at the surface of the water in Pensacola Bay, May 21, 1878. Later in the season I saw large schools of them in shoal water along the sea-beach swimming towards the harbor mouth. On June 14 a very large school of them came into the surf near Fort McRae, and large numbers were thrown ashore by the waves, until perfect windrows of dead fish were found upon the sands. Sharks and other fishes were preying upon them in the water, and vast numbers of sea-birds and buzzards awaited them on land. The individuals composing this school were of various sizes, the majority being adults. (Several of these were sent to the National Museum.) They were evidently moving towards the bay. Small schools were seen during the months of July of that and the following year."

93. THE SURGEON-FISH FAMILY—ACANTHURIDÆ.

On the coast of Florida, as well as through the West Indies and in the Bermudas, occur two species of this family, *Acanthurus cæruleus* and *A. nigricans*, generally known as "Doctor-fish" or "Surgeon-fish." They are distinguished by slight differences of proportion and color. Each side of the tail is provided with a sharp, lancet-like spine, which, when at rest, is received into a sheath, but it may be thrust out at right angles to the body, and used as a weapon of offense; sweeping the tail from side to side as they swim, they can inflict very serious wounds, and I have seen, in the Bermudas, large fishes, confined in the same aquarium tank with them, covered with gashes inflicted in this manner. They are available for food, but are more worthy of consideration on account of their power of wounding the fishermen. The "Bone-fish" of Key West, according to Stearns, belongs to this family and genus. It is quite common about the coral reefs of the South Florida coast.

94. THE ANGEL-FISH FAMILY—CHÆTODONTIDÆ.

This family contains numerous species of fully-formed, beautifully-tinted fishes, usually of small size, which abound in all tropical seas, especially among the coral reefs. Their teeth are very small and feeble, and they feed upon minute invertebrates. To this group belong the beautiful "four-eyed fish" of the West Indies; also the Angel-fish, *Holacanthus ciliaris*, a lovely species, familiar to the residents of New York, specimens having been brought from the Bermudas at various times during the past thirty years for exhibition in the aquaria of that city. This species is found also along the Florida coast, and as far north as Charleston, South Carolina. It is considered the most delicious food-fish of the Bermudas.

Stearns writes: "The 'White Angel-fish,' the 'Yellow Angel-fish,' and the 'Black Angel-fish' are reported as common about the Florida reefs, the two first as being abundant and the last as rare. I did not secure a specimen of either."

The Black Angel-fish is probably the species known under this name in the Bermudas, *Holacanthus tricolor*.

L.—THE MACKEREL AND ITS ALLIES.

95. THE MACKEREL—SCOMBER SCOMBRUS.

GEOGRAPHICAL DISTRIBUTION.—The common Mackerel, *Scomber scombrus*, is an inhabitant of the North Atlantic Ocean. On our coast its southern limit is in the neighborhood of Cape Hatteras in early spring. The fishing schooners of New England find schools of them in this region at some distance from the shore, but there is no record of their having been taken in any numbers in shoal water south of Long Island. A. W. Simpson states that the species has been observed in the sounds about Cape Hatteras in August, September, and October. R. E. Earll finds evidence that stragglers occasionally enter the Chesapeake. Along the coasts of the Middle States and of New England Mackerel abound throughout the summer months, and are also found in great numbers in the Gulf of Saint Lawrence, where, in past years, fishermen of the United States congregated in great numbers to participate in their capture. They are also found on the coast of Labrador, though there is no evidence that they ordinarily frequent the waters north of the Straits of Belle Isle.

Captain Atwood[1] has expressed the opinion that they visit Northern Labrador only in seasons remarkable for the prevalence of westerly winds, and that in other seasons they do not go so far north.

Professor Hind was told by the residents of Aillik and Kypokok, Labrador, one hundred and fifty miles northwest of Hamilton Inlet, that Mackerel were abundant there in 1871, and that a few were caught in cod-seines. While at Double Island harbor, some fifteen miles north of Hopedale, a French Canadian resident informed him that there is "a scattering of Mackerel" on that part of the coast.

They appear also at times to have been abundant on the northeastern coast of Newfoundland, though their appearance there is quite irregular. Mackerel do not occur in Hudson's Bay nor on the coast of Greenland. It seems probable that the natural northern limit of the species in the Western Atlantic is not far from the Straits of Belle Isle. Professor Packard, who visited this region in 1866, recorded that a few Mackerel are taken in August in Salmon Bay and Red Bay, but that the Straits of Belle Isle were evidently the northern limits of the genus, while Fortin, one of the best Canadian authorities on fisheries, in his annual report for 1864, stated that in summer they appear in some places, such as Little Mecattina, on the adjoining coast, latitude 50½° north, and even sometimes enter the Straits of Belle Isle.[2]

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[1] Proceedings, Boston Society of Natural History, vol. 10, p. 66.

[2] In 1860 Capt. Peter Avery, of the schooner Alabama, of Provincetown, took 100 barrels of fat Mackerel at Port au Port, Newfoundland. Captain Atwood, however, has seen them at the Bay of Islands. He has also seen large schools at Mecattina.

Capt. J. W. Collins writes: "As early as 1837 or 1838, Capt. Stephen Rich, of Gloucester, spent almost the entire mackerel-fishing season on the coast of Labrador in pursuit of Mackerel. He was induced by the reports brought him by the Labrador cod-fishermen to make this attempt. They had reported seeing Mackerel abundant in the vicinity of the Straits of Belle Isle, and Captain Rich, being of an adventurous turn, decided to devote one summer to the investigation of the subject, feeling in hopes of obtaining a large catch. My father was one of the crew, and I have often heard him tell that the trip was entirely unsuccessful, notwithstanding the fact that they cruised all the way from Mecattina Islands through the Straits of Belle Isle, and on the northwest coast of Newfoundland as far down as the Bay of Islands. Few or no Mackerel were taken until the vessel returned in the fall to the southern part of the Gulf of Saint Lawrence, where a small fare was obtained in a few weeks' fishing."

Perley says that they are rarely known to visit the coast of Labrador. H. R. Storer, after carefully studying the fauna of Southern Labrador, in 1849, came to the conclusion that they were sometimes found at Little Mecattina.

In the various reports of the Canadian inspectors of fisheries on the Labrador coast from 1864 to 1870 may be found evidence that Mackerel are rarely taken even on the Labrador coast of the Gulf of Saint Lawrence.

Professor Verrill, who visited Anticosti and Mingan in 1861, was unable to find any Mackerel in the waters of that region, although the best methods of catching them were often used.

Some years ago Mackerel were abundant in the Bay of Fundy, as many as twelve vessels from Eastport, besides others, being engaged in their capture, chiefly about Digby and Saint Mary's Bay. They have now so completely disappeared as not to form an item in the commercial record of the catch.

The species is found throughout the entire length of the Norwegian coast from the Christiania Fjord to the North Cape and Varanger Fjord, latitude 71°. It occurs on the south coast of Sweden, and, entering the Baltic, is found along the shores of Eastern Denmark and Eastern Prussia, and also abundantly in the German Ocean and the English Channel, as well as everywhere in all parts of the British Isles, and southward to the Mediterranean, where it abounds, especially in the Adriatic. There is no record of its capture in Africa, South America, in the West Indies, the Gulf of Mexico, or even about the Bermudas.

The Mackerel, then, would appear to be a shore-loving fish, not addicted to wide wanderings in the ocean, and with range limited in the Western Atlantic between latitudes 35° and 56°; in the Eastern Atlantic between 36° and 71°.

MIGRATIONS.—The migrations of the Mackerel, the causes of their appearance and disappearance at certain seasons at different points along the coast, the causes of their relative abundance and scarcity in different years, have previously been discussed by numerous writers. The subject has received special attention on account of the disputes between our own and the Canadian Government concerning the value to our fishermen of the right to participate in the mackerel fisheries in the Provincial waters.

Notwithstanding the great amount of paper which has been covered with theories to explain the various mooted questions, it cannot be said that the habits of the Mackerel are understood at all better than those of other fishes which have not attracted so much attention. The most voluminous writer upon this subject has been Prof. Henry Youle Hind, who devotes many pages of his book, "The Effect of the Fishery Clauses of the Treaty of Washington on the Fisheries and Fishermen of British North America," to the attempt to prove that the Mackerel which have been at certain seasons in the past so abundant in the Gulf of Saint Lawrence and on the Atlantic coast of Nova Scotia remain there throughout the year, hibernating in deep waters not very remote from the shore.[1] I have attempted to show the weakness of his argument in an essay published in the

[1] Mr. Barnet Phillips, in the New York Times, December 31, 1880, thus criticises the theory of Mr. Hind, while referring to Mr. William H. Rideing's essay entitled "First Families of the Atlantic":

"In an article entitled 'First Families of the Atlantic,' to be found in the January number of Harper's Magazine, certain assertions are advanced in regard to the habits of the Mackerel which are entirely of an *ex parte* character, and might unintentionally act injuriously to our interests in case future disputes arose between the Provinces and the United States on the fishery question. The writer states that, 'seeking a soft muddy or sandy bed at the approach of winter, it [the Mackerel] buries itself therein, first drawing a scale or film over each eye.' In a prior paragraph of this same article the possibility of the hibernation of the Mackerel is advanced. Now, exactly these two arguments were presented by Professor Hind, who wished to prove that the Mackerel was a local fish, in favor of the Provinces, which assertions were entirely refuted by Prof. Spencer F. Baird, Secretary of the Smithsonian Institution, and by Prof. G. Brown Goode. *The great argument used by the Provincial fish experts was to show that the* Mackerel belonged to their waters, and the ideas of hibernation were therefore represented. If this had been granted, our case

Fifth Annual Report of the United States Commissioner of Fisheries for the year 1877, pp. 50–70. It is by no means demonstrated that certain schools of Mackerel do not remain throughout the year in waters adjacent to the coast of Canada, but the weight of evidence at present seems to rest with those who believe that the Mackerel are given to extensive migrations north and south along our coasts. These migrations are believed to be carried on in connection with another kind of migration which I have called "bathic migration," and which consists in a movement, at the approach of cold weather, into the deeper waters of the ocean. The menhaden and many other fishes have these two kinds of migrations, littoral and bathic. The sea-herring, on the other hand, has extensive littoral migrations and probably very slight movements of a bathic nature. In some the latter is most extended, in others the former. Anadromous fishes, like the shad and the alewife, very probably strike directly out to sea without ranging to any great degree northward or southward, while others, of which the Mackerel is a fair type, undoubtedly make great coastwise migrations, though their bathic migrations may, without any great inconsistency, be as great as those which range less.

Upon this point I cannot do better than to quote from a manuscript letter from Professor Baird to the Hon. Hamilton Fish, Secretary of State, dated July 21, 1873. Having expressed certain views concerning the well-known phenomenon of the migration of the herring and shad, he continues:

"The fish of the Mackerel family form a marked exception to this rule. While the alewife and shad generally swim low in the water, their presence not being indicated at the surface, the Mackerel swim near the surface, sometimes far out to sea, and their movements can be readily followed. The North American species consist of fish which as certainly, for the most part at least, have a migration along our coast northward in spring and southward in autumn, as do the throngs of pleasure-seekers, and their habit of schooling on the surface of the water enables us to determine this fact with great precision. Whatever may be the theories of others on the subject, the American mackerel-fisher knows perfectly well that in the spring he may find the schools of Mackerel off Cape Henry, and that he can follow them northward day by day as they move in countless myriads on to the coasts of Maine and Nova Scotia."

The movements of the mackerel schools, like those of the menhaden, appear to be regulated solely by the temperature of the ocean.

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would have had, as far as Mackerel go, little to rest upon. As to hibernation of the Mackerel there are innumerable reasons to suppose that nothing of the kind exists. In fact, hibernation is one of those ichthyological questions which require very long research to know anything about. It does seem that sturgeon in Russian waters, and carp in cold temperatures, take to the mud, and may, perhaps, do something like hibernation, but this habit has no precedent in sea-fish. It may happen that a few individuals of the *Scomber* family have been inclosed in the winter season in the waters of the Newfoundland coast. Such cases have undoubtedly happened, for on page 62 of the late report of the United States Commission the statement is made that in a river of Nova Scotia where a school of Mackerel had been detained the fish were speared out of the mud. Returning to the numbing effects of cold weather on sea-fish, in order to show how unusual it must be, the American turbot is taken with hooks in the dead of winter under the floe ice of North Greenland at a depth of 300 fathoms. If sea-fish were mummified in the ocean depths by the cold, because at the deeper strata of the ocean temperatures are fairly uniform, once a fish had hibernated his sleep might continue on forever. There can be no better proof of the migratory character of the Mackerel than to cite a paragraph from the 'Cape Ann Advertiser,' published this week, where the fact is announced that the mackerel fleet have gone off Hatteras in hopes of securing Mackerel, and that some time ago 'vessels reported having sailed through immense schools for forty miles.' The film over the eye of Mackerel Professor Hind placed great stress on, as he supposed it was a preparatory step to the hibernating process. Now, this film over the eye, as Mr. Goode shows, is not peculiar to the *scombers*, for many fish, such as the shad, the alewife, the menhaden, the bluefish, the mullet, the lake whitefish, and various cyprinoid fishes, have this membrane, though it never does cover the whole eye. The fact remains also to be proved that a skin forms over the eye in winter only. The writer of this article has apparently culled his facts in regard to Mackerel from one side, and has read most superficially the whole of the testimony. 'Public documents' are rarely of an amusing character, but when they happen to be of interest, as were those published as 'The Award of the Fisheries Commission,' it is most unfortunate when false deductions are derived from them."

In my essay upon menhaden, which has just been referred to, I have attempted to show, in a preliminary way, the relations of the movements of the menhaden schools to the temperature of the water at different stations along the coast in accordance with certain crude observations, which at present constitute the only material available as a basis for such generalizations. I have there claimed that menhaden make their appearance near the shore in the spring as soon as the temperature of the water in the harbors has reached a weekly average of 50°, and that they disappear in the fall soon after the waters have again cooled down to the same average temperature.

The Mackerel are partial to much colder waters. They range ten to fifteen degrees farther to the north, and their southern limit is proportionally high. They appear earlier in the spring and disappear later in the fall, and their presence is nearly synchronous with the time when the water temperatures of the harbor have reached a weekly average of 45°. It has been remarked that the presence of the menhaden depends upon a weekly average of the harbor temperature of 50° or more. These harbor temperatures are several degrees—it is not known exactly how many—higher than those of the open ocean at the same latitude, and there can be no question that the menhaden thrives in water as cold as 45°. Mackerel will remain active and contented in a temperature of 40°, or even less. The normal time of the departure of Mackerel from the coast is, therefore, a month or two later than that of the menhaden.

There are well recorded instances of the capture of menhaden in Massachusetts Bay as late as December, and there are also many instances where Mackerel have been taken not only on the New England coast, but also in the Gulf of Saint Lawrence, in midwinter.[1]

Mr. John Fletcher Wonson tells me that at one time he left Gloucester on a halibut trip January 1, and January 3 or 4, on George's Bank, caught a hogshead of herring and seven or eight Mackerel in a gill-net. Schooner "Shooting Star" took a number of Mackerel on George's Bank in March, 1856.[2]

The fishermen on George's took Tinkers from the stomachs of codfish in February, 1878, using them for bait. Sometimes five or six were taken from one fish.

In January, 1868 or 1869, Capt. Warren Brown, of the schooner "Charles Frederick," of Gloucester, caught thirty Mackerel on a trawl-line set on the Middle Bank.

The "Yarmouth Herald" (Yarmouth, Nova Scotia), January 2, 1879, states that "two fine, fat, fresh Mackerel were found among the kelp at Green Cove on Friday, December 28, 1878."

Basing their arguments upon such occurrences as these, Canadian writers have attempted to prove that large bodies of Mackerel hibernate along their shores in the winter months. It is still believed by many fishermen that the Mackerel, at the approach of cold weather, go down into the mud and there remain in a state of torpidity until the approach of warm weather in spring. All that can be said regarding this claim is that, although we do not know enough about the subject to pronounce this impossible, American ichthyologists think they know enough to be of the opinion that it is very decidedly improbable.

It seems only fair to quote in this connection a letter printed in "Forest and Stream," a leading New York journal devoted to field sports and the fisheries, in criticism of views published at the

[1] Twenty Mackerel were caught in a gill-net at Provincetown January 17, 1878. Others were taken late in December. Captain Harding tells me that they sometimes come ashore frozen in cold weather, and are found in the ice on the beach.

Early in February, 1881, small Mackerel five or six inches in length were found in considerable numbers in the stomachs of hake and cod, taken on the eastern part of George's Bank in fifty fathoms, and on the southeastern part of Le Have in sixty and eighty fathoms of water; sometimes ten, twelve, or fifteen in the stomach of a single fish. On the 8th and 9th of February, Captain Olsen observed them schooling at the surface on George's. Gloucester fishermen had before seen them in winter on George's, but never so abundant.

[2] "Gloucester Advertiser," April, 1856.

time in that paper, and also in the Report of the Fish Commission, part v. I feel the utmost confidence in Dr. Gilpin's statements as to facts observed, though my interpretation might perhaps be different:

HALIFAX, *June* 19, 1878.

MR. EDITOR: In some papers published some time since in the "Forest and Stream" upon the habits of the Mackerel, it is asserted by Prof. Brown Goode that there is no reliable evidence of Mackerel being seen upon the coast of Nova Scotia after the 25th of October, quoting me as his authority. Had he quoted me as giving the 1st of November, 1868, when the fish market at Halifax was full, I should have felt more complimented, as I should have known he had read my paper with more attention. In summing up my remarks I stated that Mackerel remain usually all November on the surface in Nova Scotia, and during mild winters linger to December. This, Professor Goode says, is not reliable as scientific evidence, because no specific dates are given. To admit this would be to destroy almost the whole mass of information compiled in the report of both the Royal and American Commissioners of English and American fisheries. But as I am certain that Professor Goode's desire is to have the truth simply, will you allow me a place in your columns to add to my previous assertions such specific dates as I may be able now to obtain, though not admitting his principle?

On May 23, 1875, going into the Halifax fish market, I asked generally how long are Mackerel in market. I was answered, generally all through November. On asking how long in December they had known them in market, Mr. Greywire said: "I recollect them as late as the 10th of December. We keep our nets out to the 30th of November. Men hire to that time. Mackerel are seen after that date, but the seas are so boisterous that our nets are destroyed. Some few parties will keep them out in December in spite of cold and storms." Mr. White corroborated this. Mr. Thomas Brackett said he had taken them often in December, and often in weather so cold that the fish were frozen in removing them from the meshes of the nets, but could remember no dates. Mr. William Duffy stated he saw one once on the 24th of December. He recollected it because it was Christmas eve, and on account of its rarity; but he had frequently taken them during December, though having no dates. The nets used are about two fathoms deep, set near the shore in about five to ten fathoms of water. My own recollections, but without dates, are seeing stops made in very cold weather and frozen ground, which must have been late in November. I think I have now made good my assertion that they linger to December, and that in any future history of their habits it must be assumed as truth that they remain in numbers during November, but are found sparingly later on our coasts. Where they are during those dates in any intermediate point from Maine to Virginia, must be left to American observers. When these blanks are filled and a generalization made their history will be more complete, a task we may well leave in the hands of the American Commissioners of Fisheries.

In my paper (1865) I speak of their asserted torpidity and the story of their blindness as needing more proof before they are asserted as facts. I have had nothing to alter my opinion since. In examining the eyes of many Mackerel on May 23 and 27 and October 27, in different years, I have found that, as in most fish, the bony orbit is much larger than the base of the eye, and that the space is filled by gelatinous substance, which may be called cellular membrane, and adipose deposit to this transparent membrane arising from the outer angle of this orbit and spreading half over the pupil of the eye. It may easily be raised and defined by passing a penknife between it and the eye. At the inner angle there is also a similar, but much smaller, membrane, not reaching to the eye. As the Mackerel appear on our coasts about the 15th of May, and these

observations were made the 23d, I do not think it can be asserted the eye is closed entirely in spring; and as the same appearance is found in September, we must admit it to be a permanent structure. An analogous membrane is found in the *Clupeidæ* and doubtless other fish. On asking *Thomas Loyd, our roughest and oldest fisherman: "I don't know anything about the scales of the* eyes, but I do know that, curse them, they see too sharp for us, steering clear of our spring nets," and doubtless old Tom was right.

On dissecting a Mackerel, May 23, I found the heart first presenting the tricornered ventricle with its white aorta and deep-red auricle resting upon the fringe of cœca that covered the intestines, sweeping down to the vent. The liver and stomach were both covered by the cœca. The latter was about three inches long, its upper lobe thick and round, but ending in a narrow tail or point. The cardiac end of the stomach was prolonged two and a half inches, ending in a point. The cœca were attached to the gut about an inch below the pylorus. There was but little difference in appearance and size between stomach and gut. This we may roughly sum up: Stomach and gut very simple; cœca usually large and complicated; liver small—all noteworthy facts in the study of *comparative life. The fish being a male one, lobe on either side of ivory-white; milt* reached from gills to vent, slightly adhering to the sides by thin membrane, and covered by a similar one. They were divided in lobes by shallow lines, the upper lobes slightly fimbriated. On removing both entrails and milt a dark purple space about an inch wide extended from gills to *vent beneath the back bone. This, when opened, seemed filled with coagulated blood. It had in* some respects the appearance of the air-bladder in the *Salmonidæ*, though wanting in the direct communication they have with the œsophagus. But this communication is also wanting in the *Gadidæ, where, especially in the hake, the air-bladder assumes its highest form of organization.* I have often found coagulation and reticulated plexi in air-bladders of other fish.

It has been asserted the European Mackerel have no air-bladders, and a new genus proposed, but with more probability they have the same organization as our own, and the difference lies in the opinion whether or not it is an air-bladder.

The Mackerel appear on the Atlantic coast of Nova Scotia, and almost simultaneously on the Bay of Fundy, about the 15th of May. Nearly all spawners, male and female, perform a somewhat easterly and northerly route, disappear from the surface in a few weeks and reappear again in September without spawn and fat, remain in numbers during November, and very sparingly during December, coming from the eastward, and then disappear. It may be asserted, generalizing from observation extending over a series of eight or ten years, that they are irregular in their movements as regards localities, though probably not as regards ocean surfaces.

The very great difficulty of accounting how these enormous masses of surface feeders find food after disappearing from the surface has caused many ingenious theories as to the question in *what state and where they pass that time. These are all pleasant reading, but valuable more or* less as regards the ingenuity and scientific standing of the writers. In this paper and the one I inclose (1865) I have stated what I think are facts, and which must be accepted in the future history of American Mackerel, which I hope soon to see written by that commission which has already done so much in Atlantic waters.

BERNARD GILPIN.

The appearance of the mackerel schools at the approach of summer in ordinary years has been noticed somewhere in the neighborhood of the following dates: At sea, off Cape Hatteras, March 20 to April 25; off Norfolk, Virginia, March 2 to April 30; off the Capes of Delaware, April 15 to May 1; *off Barnegat and Sandy Hook, May 5 to May 25,* and at the same date along the whole

southern coast of New England, and as far east as Southern Nova Scotia, while in the Gulf of Saint Lawrence they appear late in May, and in abundance early in June.[1]

There appears to be a marked difference between the movements of Mackerel and the menhaden, for while the menhaden are much more gradual in their approach to the shore, and much more dependent upon a small rise of temperature, the Mackerel make their appearance almost simultaneously in all the waters from New Jersey to Nova Scotia at about the same time. Stragglers, of course, appear much earlier than the dates just mentioned; a few Mackerel were observed at Waquoit, Massachusetts, as early as April 19, 1871.

In the fall the Mackerel disappear as suddenly as they came in the spring, but they have only in one instance been observed off the Carolina coast, except during the spring run. This is very probably because no fishing vessels ever visit this region later than June.

The instance referred to is the experience of Mr. Peter Sinclair, a well-known fisherman of Gloucester, who states that he has frequently taken them in great abundance off Cape Hatteras in December, where they are not known at all in the summer season. He has found them in the spring as far south as Charleston, and followed them from Cape Henry to the Bay of Fundy and the Gulf of Saint Lawrence.

The very vagueness of the statements just made is evidence to show how little is actually known about the movements of these fish. The subject must be studied long and carefully before it can be understood, and the interests of the American fishermen demand that it should be thus studied.

"There is," writes Professor Baird, "no very satisfactory evidence of the occurrence of Mackerel in the winter or any other season south of Cape Hatteras, and it is not given by Poey and other writers as occurring in the West Indies. A few Mackerel are said to be occasionally brought into the Charleston market, and Mr. Moses Tarr, of Gloucester, thinks that some years ago he saw in the early part of March, a short distance to the southeast of Key West, a large school of Mackerel. He, however, did not capture any, and it is more likely that the fish observed belonged to some other small species of the mackerel family which occasionally school like the Mackerel itself, and might easily be mistaken for it. The skip-jack or leather-back may possibly have been the species referred to.

"I have been quite surprised to find the extent of belief among Massachusetts fishermen that the Mackerel goes into the mud in the winter time. I have, indeed, been assured by trustworthy parties that they have known Mackerel caught on eel spears when fishing for eels in the mud of Provincetown harbor.

"A similar belief is referred to by Dr. Gilpin in his paper on the Mackerel in the Transactions of the Nova Scotia Scientific Association, and it is difficult to refuse assent to the testimony of otherwise credible observers. There is nothing apparently in the economy of the Mackerel to prevent its following the example of the sand lance, the eel, and other fish. We know that the

[1] The following letter from the skipper of the schooner "Edward E. Webster" is important, in that it gives the exact positions as well as the dates of some of the earliest captures in 1878, '79, '80, and '81:

NEW YORK, *April* 22, 1881.

Captain COLLINS:

DEAR SIR: I have just received your letter of March 14, in which you wanted to know whereabouts I caught my first Mackerel. The first catch in 1878, April 16, lat. 36° 10′ N., long. 74° 45′ W.; in 1879, April 12, lat. 36° 35′ N., long. 74° 50′ W.; in 1880, April 1, lat. 35° 30′ N., long. 74° 15′ W.; in 1881, March 20, lat. 37° 10′ N., long. 74° 05′ W.; and this trip we got them April 18 in lat. 38° 38′ N., and long. 74° 00′ W. This is our second trip this season. I have seen Mackerel in lat. 35° 15′ N. and long. 73° 46′ W., which is the farthest south I have ever seen any. I have been off Cape Lookout many times, but have never seen Mackerel there. . . .

Yours, truly,

SOLOMON JACOBS.

melanora, the tench, and many other fresh-water fish have the burrowing habit, some of them being imbedded very deep in the mud at the bottom of a dried-up pond, to emerge again when the water is restored.

"The entire disappearance of Mackerel during the winter season is a noteworthy fact, as we can hardly suppose that if it schooled on the surface in the Gulf Stream during that season it would not be noticed by the experienced eyes of sea captains, and we can hardly imagine that the fish would remain in the depths without an occasional rise.

"It appears to be a well-established fact that Mackerel are not unfrequently found in the stomachs of cod, and possibly of halibut, taken on the George's Banks in the winter season. Perhaps the number noted would be still larger if fishermen had the time and inclination to examine more frequently than they do the stomachs of the fish captured by them.

"Another curious fact in relation to the Mackerel is in respect to the membrane, the vertical edge of which is observed during the summer season on the corner of the eye. This, it is claimed, during the winter extends over the whole eye, and imparts the appearance of blindness. This the Mackerel is said to possess on making its first appearance near the coast in the spring, when it extends over the greater part of the eye, thus preventing the fish from seeing the bait, and it is a matter of common remark that Mackerel in the spring cannot be taken with the hook, but must be captured with the net. The membrane appears to recede with the advancing season, and during a considerable portion of the time of its abode in the north it is scarcely appreciable."

Mr. Perley, of Saint John, New Brunswick, in his work upon the fishes of the Provinces, remarks that Mackerel have been taken on cod-hooks in deep water, near Grand Manan, in the winter season, and there is evidence to show that a few remain on the coast. It is, however, believed that these cases are exceptional and confined to stragglers, as such instances frequently occur with all the migratory fishes.

The Mackerel belongs to what may technically be termed pelagic or wandering fish, as their movements, something like those of the herring, are apparently more or less capricious, though probably governed by some definite law, which has not yet been worked out. It moves in large schools or bands, more or less isolated from each other, which sometimes swim near the surface and give distinct evidence of their presence, and at others sink down into the depths of the ocean and are entirely withdrawn from observation. The army of fish, however, moves along with a very broad front, a portion coming so close to the shore as to be taken in the weirs and traps along the coast of the Middle States, especially in Vineyard Sound and on Cape Cod; while at the same time other schools are met with from twenty to fifty miles, or even more, out to sea. It is, however, still a question whether the fish that skirt the coast of the United States enter the Bay of Saint Lawrence, or whether the latter belong to another series, coming directly from the deep seas off the Newfoundland and Nova Scotia coast. Until lately the former has been the generally accepted theory, in view of the alleged fact that the fishermen of the Nova Scotia coast always take the fish coming from the west in the spring and from the east in the fall.

Capt. Hanson B. Joyce, of Swan's Island, Maine, one of the most expert and observing mackerel-fishermen of New England, thinks that the movements of the spring schools of Mackerel are very much influenced by the direction and force of the prevailing winds while the fish are performing their northerly migration. He has generally found, he says, that when there has been a continuance of strong northerly winds about the last of May and early in June, the season at which the Mackerel are passing the shoals of Nantucket and George's Bank, the schools have taken a southerly track, passing to the southward of George's Shoals and continuing on in an easterly direction to the coast of Nova Scotia, and thence to the Gulf of Saint Lawrence.

When southerly winds or calms prevail at that season the Mackerel are carried into the waters of the Gulf of Maine, and in consequence are much plentier off the New England coast than in the Saint Lawrence Gulf.

On this theory Captain Joyce bases his actions in cruising for Mackerel, always fishing off the New England shores when southerly winds have predominated in the spring, and going to the Saint Lawrence if northerly winds have been exceptionally strong and continuous about the last of May.

The movements of the fish, as already stated, season by season, are quite uncertain, sometimes being very abundant in one direction and sometimes in another, and occasionally, indeed, they may disappear almost entirely for several years, subsequently reappearing after a considerable absence. In some years the fish are very abundant on the coast of the United States, and at others rare; the same condition applying to the fish of the Bay of Saint Lawrence. It is not certain, of course, that this indicates an entire absence of the fish from the localities referred to, but they may, possibly, for some reason, remain in the depth of the sea, or some change in the character of the animal life in it, which constitutes the food of the fish, may produce the changes referred to. A notable instance of a somewhat permanent change in the migration of the Mackerel is found in the entire failure since 1876 of the mackerel fishery in the Bay of Fundy, which, a few years ago, enabled a merchant of Eastport to employ successfully as many as a dozen vessels, especially in Digby and Saint Mary's Bays, but which is now abandoned. There are indeed faint suggestions, in the early history of the country, of their total absence from the whole coast for several years, as was also the case with the bluefish.

ABUNDANCE.—The wonderful abundance of Mackerel in our waters has always been a subject of remark. Francis Higginson, in his "Journal of his Voyage to New England, 1629," speaks of seeing "many schools of Mackerel, infinite multitudes on every side of our ship," off Cape Ann on the 26th of June; and Richard Mather, in his "journal," 1635, states that the seamen took abundance of Mackerel off Menhiggin (Monhegan). In Governor Winthrop's journal, speaking of the year 1639, he remarks: "There was such store of exceeding large and fat Mackerel upon our coast this season as was a great benefit to all our Plantations, since one Boat with three men would take in a week ten hogsheads, which were sold at Connecticut for £3 12*s*. 0*d*. per hogshead."

Their abundance has varied greatly from year to year, and at times their numbers have been so few that grave apprehensions have been felt lest they should soon depart altogether.

As early as 1670, laws were passed by the colony of Massachusetts forbidding the use of certain instruments of capture, and similar ordinances have been passed from time to time ever since. The first resource of our State governments has always been, in seasons of scarcity, to attempt to restore fish to their former abundance by protective legislation. It seems to us at the present day absurd that the Massachusetts people should have supposed that the use of shore-seines was exterminating the Mackerel on the coast of Massachusetts, but it is a fair question whether their apprehensions were not as well grounded as those of legislators of the present century who have endeavored to apply a similar remedy for a similar evil. In connection with the chapter on THE MACKEREL FISHERY will be shown a diagram, which, by means of curves, exhibits the catch of Mackerel in New England for a period of seventy-five years.

From a study of this it seems quite evident that the periods of their abundance and scarcity have alternated with each other without reference to overfishing or any other causes which we are prepared to understand. In the year 383,548½ barrels of Mackerel were caught by the citizens of Massachusetts. In 1881 the number of barrels salted was 269,495; to this, however, should be added 125,000 barrels caught and marketed fresh by the Massachusetts fleet, making an aggregate

of 394,495 barrels. The fluctuations in the catch year by year from 1804 to 1881 are shown most instructively in a plate accompanying this report.

The stories which are told by experienced fishermen of the immense numbers of Mackerel sometimes seen are almost incredible. Capt. King Harding, of Swampscott, Mass., described to me a school which he saw in the South Channel in 1848: "It was a windrow of fish," said he; "it was about half a mile wide, and at least twenty miles long, for vessels not in sight of each other saw it at about the same time. All the vessels out saw this school the same day." He saw a school off Block Island, 1877, which he estimated to contain one million barrels. He could see only one edge of it at a time.

Upon the abundance of Mackerel depends the welfare of many thousands of the citizens of Massachusetts and Maine. The success of the mackerel fishery is much more uncertain than that of the cod fishery, for instance, for the supply of cod is quite uniform from year to year. The prospects of each season are eagerly discussed from week to week in thousands of little circles along the coast, and are chronicled by the local press. The story of each successful trip is passed from mouth to mouth, and is a matter of general congratulation in each fishing community. A review of the results of the American mackerel fishery, and of the movements of the fish in each part of the season, would be an important contribution to the literature of the American fisheries. Materials for such a review are before me, but space will not allow that it should be presented here.

Food of the Mackerel.—The food of the Mackerel consists, for the most part, of small species of crustaceans, which abound everywhere in the sea, and which they appear to follow in their migrations. They also feed upon the spawn of other fishes and upon the spawn of lobsters, and prey greedily upon young fish of all kinds.[1] In the stomach of a "Tinker" Mackerel, taken in Fisher's Island Sound, November 7, 1877, Dr. Bean found the remains of six kinds of fishes—of the anchovy, sand-lants, the smelt, the hake, the barracuda, and the silver-sides, besides numerous shrimps and other crustaceans. Captain Atwood states that when large enough they devour greedily large numbers of young herring several months old. Specimens taken July 18, 1871, twenty miles south of Noman's Land, contained numerous specimens of the big-eyed shrimps, *Thysanopoda*, larval crabs in the *zoea* and *megalops* stages, the young of hermit crabs, the young lady crabs, *Platyonichus ocellatus*, the young of two undetermined Macrura, numerous Copepoda and numerous specimens of *Spirialis Gouldii*, a species of Pteropod. They also feed upon the centers of floating jelly-fishes (discophores). In Gaspé the fishermen call jelly-fishes "mackerel bait."

The greed with which Mackerel feed upon the chum, or ground menhaden bait, which is thrown out to them by the fishing-vessels, shows that they are not at all dainty in their diet, and will swallow without hesitation any kind of floating organic matter.

Large Mackerel often eat smaller ones. Captain Collins has frequently found young Mackerel three or four inches long in the stomachs of those full grown. This is generally noticeable only in the fall, and the young fish are probably those which have been hatched in the spring.

In the fall of 1874 the writer made a trip upon a gill-net schooner to the grounds off Portland, Maine, some distance to sea, for the purpose of studying the food of the Mackerel, and found their stomachs full of a species of *Thysanopoda* and of a large copepod crustacean. The greater part of the food of Mackerel consists, however, of minute crustaceans. Owing to the infinite abundance of these in the sea, Mackerel probably have very little difficulty in finding food at almost any portion of the ocean visited by them, whether on the edge of the Gulf Stream or near the shore.

[1] Near the New London light-house is a small brook which empties into the harbor and abounds with a small species of fish of which the Mackerel appear to be fond. A few days since the keeper of the light-house, while the Mackerel were indulging in a meal, caught five hundred at one haul with a scoop-net.—Gloucester Telegraph, December 3, 1870.

In an interview with Capt. King Harding, of Swampscott, one of the most experienced mackerel catchers on our coasts, I obtained the following amusing observations: He described one kind of crustacean Mackerel food which looked like spiders, which were red, and crawled over his hand when he took them up. They look like little spiders; the Mackerel are especially fond of them. At Boone Island, Maine, in July, 1850, the water all around the island was red for one hundred yards from the shore; these crawled up the rock-weed on the shore until it was red. He took the sprays of rock-weed in his hands and pulled them slowly to him, and the Mackerel, one and a half pound fish, would follow in quite to the rocks. He killed three with his oar, and tried to catch some in a basket by tolling them over it, but they were too quick for him. He asked his old skipper, Capt. Gorham Babson, what they were, and was told that they were "Boone Island bed-bugs." And, said he, "Young man, when you see this kind of bait, no matter if you don't see any fish, never leave; the fish will be there in a few days."

Then there is another kind, called "snappers." These are white, and dart rapidly about in the water; they are doubtless small crustaceans. He says that sometimes they swim at the surface, where the Mackerel follow them. A few days before he had been standing on the stern of his vessel, and though he could see nothing under the water he knew the snappers were there about two feet below the surface, for he could see a school of Mackerel swimming along, opening their mouths and taking in their food, and then letting the water out through their gills.

When the Mackerel are tolled up from twelve or fifteen fathoms below the surface their stomachs are often full of bait; so it is certain that these little animals swim at all depths.

Another kind of food is red, and is hot to the hands. This is called "Cayenne"; it spoils the fish.

Years ago, according to Captain Harding, Mackerel did not school as they do now.

When you see pollock jumping near the shore, it is a pretty good sign that there is plenty of mackerel food.

The presence of abundance of mackerel food is indicated by the great schools of sea-birds, particularly by the flocks of phalaropes, or sea-geese, as the fishermen call them, which congregate together, floating upon the water, and when seen in summer give a sure sign of the presence of Mackerel also.

The various invertebrate animals preyed upon by Mackerel are known to the fishermen by such names as "shrimp," "red-seed," and "Cayenne."

"The wide-spread distribution from shore seaward of the Thysanopoda and other minute crustacea, which constitute to so great an extent the food of the Mackerel and herring on our shores, was proved," writes Professor Baird, "during a trip of the 'Speedwell' from Salem to Halifax in 1877." At numerous points and at regular intervals on the way across, including the middle of the route, immense numbers of these shrimp were met with and collected by the towing net. They were found in especial abundance at Le Have Bank. These prove to be specifically identical with those found in immense quantities in Eastport Harbor at the surface.

"That these same animals occur at least as far east as the Gulf Stream is shown by the list of the collections made by Professor Smith off the Georges near the edge of the Gulf Stream, and published in the Transactions of the Connecticut Academy of Arts and Sciences, vol. iii, July, 1874."

Capt. Stephen Mar, of Gloucester, confirms the statements of Captain Harding regarding the effects of "red-seed" upon Mackerel; he states that when Mackerel are feeding on "red-seed" the fishermen have great trouble in keeping them sufficiently long to dress them properly. Their bellies soften at once. When the weather is good and dogfish are not troublesome, the common

practice is to allow the fish to lie in the net until they have disposed of the food in their stomachs. Capt. Henry Willard, of the schooner "Henry Willard," of Portland, Maine, carries a large net of coarse twine, which is suspended over the side of the vessel from two long booms. Into this he turns the fish and leaves them until the seed works out.[1]

Captain Mar states that the "red-seed" is very troublesome to the men engaged in dressing the fish; it makes their hands very sore, often causing the blood to run. A man can clean twice as many fish in a given time if he is not annoyed by the "red-seed" in their stomachs.

Captain Mar describes another kind of mackerel food, which he calls "small brit," which, he says, resembles young herring, which also rots the fish. This is probably, as he supposes it to be, "white-bait" in the young of the sea herring, *Clupea harengus*. It is known as "eye-bait" to the Canadian fishermen.

Captain Merchant tells me that when Mackerel are found with "red-seed" in their stomachs fishermen are sure that they are on the right fishing grounds.

I am told by Captain Collins that it is common for many of the American fishermen to consider it a good sign of Mackerel when they see floating seaweed, more especially eel-grass, "chopped up," *i. e.*, cut into short pieces, which they think is done by these fish. Perhaps there may be a good reason for this supposition, as the Mackerel, while feeding on the diminutive shells with which the weeds are covered, may also bite the latter in two. The presence of gannets is also considered a good sign of Mackerel.

In England the food of the Mackerel is called the "mackerel mint," and this is said to consist at certain seasons of the year of the sand-lants and five other fish, especially the herring and the sprat, while they have also been observed to devour, in the summer months, minute crustaceans, the swimming larvæ of tape-worms, and the embryos of the small spiral shell Rissoa, which, in its adult state, is found in great abundance upon seaweed. It is probably some animal of this kind which was referred to by Captain Harding in the statement above quoted, concerning the abundance of red-seed about Boone Island. Mr. J. F. Whiteaves has recorded a similar habit for the Mackerel of the Gulf of Saint Lawrence.[2]

Professor Hind has pointed out certain relations which exist in the Gulf of Saint Lawrence *between the Mackerel and the lant, or sand-eel, which appears to be one of its most important* articles of diet in these waters. I quote here in full his observations upon this subject, and also his views upon the relations of currents and tides to the presence of mackerel food, and the constant movements of the schools of fish:

"The movements of the Mackerel, like those of the cod, and indeed of most species of fish, are determined at different seasons of the year by the geographical position of its food; and the first important kind of food which appears to lure the Mackerel inshore, after spawning in the Gulf of Saint Lawrence, is the launce or sand-eel.

"The relation of the launce or sand-eel (*Ammodytes americanus*) to the Mackerel is very much greater than appears at the first blush, and resembles the relation of the herring to the cod in general, and in particular the relation of the so-called Norwegian 'Sull cod,' or launce cod, to this wide-spread and important bait-fish. The approach of the launce to the coast in spring is most probably the cause why the so-called spring cod fishing suddenly ceases on many banks and shoals, commencing again at different localities two and three weeks later.

"The cod leaves the banks and shoals to meet and to follow the launce as they approach the

[1] This "large net of coarse twine" is the mackerel pocket described in the chapter on THE PURSE-SEINE MACKEREL FISHERY.

[2] *Report on the Second Deep-sea Dredging Expedition of the Gulf of Saint Lawrence, 1872.*

coast. In the same manner they meet and follow the caplin, guided no doubt by the peculiar odor developed by each species at the approach of the spawning season.

"But it is the habit of the sand-eel of burying itself in the sand between the tides, or in submerged sand beaches, that leads the Mackerel so close inshore.

"There can be little doubt that a similar indraught and outdraught of Mackerel and other fish occur in our waters when the launce leave the deep sea to approach the land, or when they return to the deep sea again. Unlike many of the shrimps and larval forms on which the Mackerel feed, which are drifted to and fro by winds and currents, the launce is independent of the wind; but it is only in certain favorable localities frequented by this fish that the burying process between tide-marks, from which it derives its name, can be easily effected; hence, these resorts are not only valuable as bait grounds, but generally noted mackerel grounds, such as Seven Islands, and some parts of Bay of Chaleur, and part of the gulf coast of New Brunswick.

"This bait-fish approaches the sandy beaches fringing the shores of the gulf in the early summer months to spawn; and here the Mackerel are found pursuing them while engaged in depositing their comparatively large reddish-colored ova on the sands between high and low water. Hence, during flood tide, and in the launce season, Mackerel are commonly taken close inshore on these coasts, in pursuit of the launce; and the best catches are said to be made during the period of high tide, for the following reason: In dull, cloudy weather the launce buries itself in the sands left bare by the ebbing tides; but in bright, hot weather it rarely seeks the shelter of the sand, except near low-water mark, probably because the heat of the sun would be oppressive. The breadth of sandy ground in which the launce buries itself for the brief period between high and low water marks is thus dependent upon the clearness of the sky.

"A continuance of cloudy weather is conducive to this kind of close inshore fishery; whereas a bright sky, and a day with a drying wind, leads the launce to select the narrow bands of sandy beach near the margin of ebb-tide, which always remain moist. In cloudy weather with a moist wind, the area in which the launce bury themselves and emerge during the incoming tide is thus very much greater than in bright, hot weather; and it is not unfrequently found by experience that the Mackerel catch in such localities is much greater in cloudy weather than in bright weather, because the bait ground is then far more extensive close inshore.

"As the summer advances and the launce retire to deep water the Mackerel feed upon the free-swimming and floating embryonic forms of crustaceans; among the latter the zoea of different forms of crabs are the most common. Adult shrimps of many species form also a large portion of their food, and the infinite numbers of these forms of life which exist in the sea, from the coast line to a thousand miles from land, may be inferred from the fact that, together with fish, they form the great staple of food of seals in northern seas.

"Dr. Robert Brown states that, during the sealing season in Spitzbergen seas, he has taken out of the stomachs of seals various species of *Gammarus* (*G. Sabini; G. loricatus; G. pinguis; G. dentatus; G. mutatus*, etc.), collectively known to whalers under the name 'mountebank shrimps,' deriving the designation from their peculiar agility in water.[1]

"These small crustaceans are found in countless numbers on the great outlying banks off the North American coast, and in the Labrador seas they are also in great profusion.

"It is of special importance to notice that very many if not all of these free-swimming creatures in the sea, from invisible microscopic forms to the largest shrimp, sink to different zones of water or rise to the surface with the variations in temperature and changes in the direction and force of the wind. In fine weather, when the food is at the surface, the Mackerel, the herring, and

[1] Dr. R. Brown: On the Seals of Greenland.

other surface feeders swim open-mouthed against the wind. Dr. Brown states that the right whale and most of the whale species feed in a similar manner. The right whale feeding swims leisurely at the rate of about four miles an hour. Mackerel, when feeding, come often by millions, like a swiftly moving ripple on the water, with eager, staring eyes and mouths distended to entrap the floating prey. *Many of the free-swimming pteropoda are active only during the night-time*, sinking during the day to a certain zone of depth.

"The effect of currents and tides, assisted by winds, is to drive these free-swimming forms towards the different shores and into land-locked or sheltered bays. On the shores of the open sea a continued land breeze drives them far out to sea, and the fish following them will be lost to view. *Off the coast of the United States the Mackerel ground is not unfrequently found near the* summer limit of the Gulf Stream where wide-spreading eddies prevail, caused by the meeting of the great Labrador current flowing in an opposite direction, or the surging up of the arctic underflow. In these vast eddies the temperature is greatly reduced by the mixing of almost ice-cold water from beneath with a warm overlying stratum.

"*It is here, too, that the free-swimming mackerel food will congregate, sometimes at the surface*, at other times at different depths, dependent upon the temperature of the mixed waters. In the vicinity of the south edge of the Grand Bank of Newfoundland the line of contact between the Arctic and the Gulf Streams is sometimes very marked by the local currents which 'boil and form strong eddies.' The line of contact of the two great cold and warm currents is continually changing for hundreds of miles with the varying seasons, and under the influence of winds; hence, also, the changes in geographical position and in the depth or zone of the open-sea mackerel grounds.[1]

"Inshore the floating and free-swimming food is drifted to and fro by winds and tides, and great accumulations are sometimes thrown up upon the beaches in windrows after storms. This floating and swimming food gathers in eddies, either near the coast line or at the junction of opposing tidal waves or currents. Hence, along sheltered and embayed coasts, confronting the open sea in the vicinity of banks where great tidal currents and eddies are formed, or in the gulf and estuary of the Saint Lawrence, where two opposite and wholly different tides dragging along the coast line approach to meet, there will be the mackerel ground of the fishermen, but not necessarily *at the surface*."

The winged pteropods very properly form an important part of the mackerel food, as they sink and rise with changes of the temperature of the zone or sheet of water in which they are feeding.

REPRODUCTION.—Although little is actually known concerning the spawning habits of the Mackerel compared with those of fish which, like the shad and the salmon, have been artificially propagated, it is perhaps safe to say that the subject is understood in a general way. The testimony of reliable observers among the fishermen of our coast and the coast of the British Provinces indicates that the spawning takes place in rather deep water all along the shore from the eastern

[1] There are no mackerel-fishing grounds within 300 miles or more of the Grand Bank, and certainly none nearer than 400 miles of its southern edge. It is possible that mackerel have occasionally been seen, or stray specimens captured, nearer the Grand Bank than this, but no mackerel fishermen would think of trying for these fish east of the west coast of Newfoundland. There are but two instances on record where mackerel fishermen have gone so far east as that. Whatever influence may be exerted upon other forms of ocean life by the meeting of the Gulf Stream and the Arctic Current, it can be quite safely asserted that the Mackerel are never found in summer near the junction of these currents, excepting, perhaps, on the southern edge of George's Bank and off the south shoal of Nantucket. These localities are the nearest mackerel-fishing grounds to the Gulf Stream of any on the United States coast. And even here Mackerel are rarely or never taken nearer than fifty or sixty miles from the northern edge of the stream.—J. W. COLLINS.

end of Long Island to Eastport, Maine, along the coast of Nova Scotia, and in the Gulf of Saint Lawrence. The spawning season occurs in May in Southern New England, in May and June in Massachusetts Bay, and in June in the Gulf of Saint Lawrence, and on the Bradley Banks and about the Magdalenes early in the month, and, according to Hind, on the northeast coast of Newfoundland toward the end of the month.[1]

Capt. Benjamin Ashby, of Noank, Connecticut, states that in the spring of 1877 Mackerel spawned in great numbers in Vineyard Sound and Buzzard's Bay. Many Mackerel were taken in the pounds, and the eggs were so ripe that when the fish were thrown from the net to the boat the eggs escaped to such an extent that in cleaning out the boat afterwards he found at least half a bushel at the bottom. This was as early as the 2d of May, and continued through the month.

Capt. R. H. Hurlbert, of Gloucester, found the spawn running out of Mackerel taken off Kettle Island, south of Cape Ann, in May and June.

Capt. Henry Webb, who owns a weir on Milk Island, under the shadow of the Thatcher's Island lights, obtains many Mackerel every year in his nets. He informs me that when they first make their appearance, about the first of June, the spawn is running out of them, and many of them are half through the process of spawning. The eggs will spurt from a female fish in a stream six feet long, and there is a large percentage of females in the catch, probably two-thirds of the whole. The spawn begins to dry up after the first of August, and young fish begin to appear about the 4th of August. He thinks that it takes Mackerel four or five weeks to spawn; after that they begin to grow fat, and when they are fat there is no sign of spawn to be seen, the male and female not being distinguishable.

The growth is rapid, and in about seven weeks the young fish are about four or five inches long.

Mackerel spawn abundantly in Grover's Beach at a depth of one and a half to two fathoms. The eggs are very minute, and the old Mackerel feed upon them greedily.

Captain Fisher, of Portland, Maine, told me, in 1874, that when the Mackerel come in they are almost empty and have a muddy taste. They first engage in spawning, but toward the last of June they have finished and begin to grow fat.

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[1] During the entire month of June Mackerel are taken in the Bay of Saint Lawrence with roes fully developed. Having been engaged in the Mackerel fishery in the Gulf for twenty-two consecutive seasons, ten of which I went to the Bay early in June, I have therefore had abundant opportunity to learn the spawning season of the Mackerel in that region. It is my opinion that Mackerel spawn in the Gulf of Saint Lawrence some time between the 1st and the 15th of July. Have caught them in abundance and full of roe as late as the 4th and 5th of July, and it is exceedingly rare to find spent Mackerel previous to the 20th of June. In the period when hook-and-line fishing was most prosperous, the fishermen usually planned to leave the Gulf about the first week in July if they had succeeded in getting nearly a fare of Mackerel previous to that time, since while the fish were spawning, or between the 1st and the 15th of the month, but little could be done, as the Mackerel would not readily take the hook. The fishermen, therefore, knowing that they could catch few fish during this period, between "hay and grass," as they termed it, usually improved the opportunity thus afforded of making their passage home and refitting for another trip with comparatively little loss of time. Apparently one of the most favorite breeding grounds for Mackerel in the Gulf of Saint Lawrence is the area along the shores of New Brunswick and Prince Edward Island (on the north side of the latter) lying inside of a line drawn from North Cape to Point Miscou. Bank Bradley is also a breeding ground for Mackerel of considerable importance. The fish seemed to assemble on the grounds mentioned above during June, in a depth varying from three to forty fathoms. The greater part, however, were found in a depth varying from ten to twenty fathoms. The spawning season being over, they usually stay on the same grounds, though later in the summer and during autumn the Mackerel were abundant around the Magdalenes and the bend of Prince Edward Island; when the fall migration takes place they move farther south. It is probable that large numbers of Mackerel may deposit their spawn around Magdalene Island, though it is worthy of note that but few or no fish have been taken in that locality on hook and line during the month of June. Considerable quantities are, however, caught by the gill-net fishermen early in June, though the catch was small compared with that formerly obtained by hook-and-line fishing in the western part of the Bay.—J. W. Collins.

Captain Hurlbert caught a dozen fish off Camden July 1, 1870, which were half spawned and had spawn running out of them.

According to Mr. Wilkins, of Two Isles, Grand Manan, the Mackerel spawn there on the rocks and sand in water from one foot to ten feet or more in depth. This is in the first half of June. The spawn is in bunches and does not float on the water.

During the spawning season Mackerel are taken in seines, as they will not bite and are then very poor. They come again in September and October, and are then taken with the hook.

Mr. Hall, of Charlottetown, Prince Edward Island, says that Mackerel spawn only once in seven years in large numbers, this period representing the interval between the successive large catches. The Mackerel strike in there about the 10th of June. They spawn about the 2d or 3d of July on the Bradley Bank to the north of Prince Edward Island. At that time they have been taken with spawn running out of them. They cease to bite for several weeks while spawning. One of the principal spawning grounds on our coast appears to be on the Nantucket Shoals, where for a period of three or four weeks after their first appearance the Mackerel hug the bottom and rarely take the hook. At this time there is a lull in the prosecution of the mackerel fishery, although before its beginning great quantities are taken in the purse-seines far south along the coast. After the close of the spawning season the old fish are said to be very poor, but take the hook greedily along the entire coast, as also before the beginning of the spawning season. Although the fish first brought to market are sold at a high price on account of their previous scarcity, it is not until after the close of the spawning season and the subsequent fattening up of the fish that they attain their highest excellence as an article of food. Fall Mackerel are well understood to be by far the best fish. Storer, in his "History of the Fishes of Massachusetts," remarks: "From the 10th of May to the 15th of June they appear at the entrance to Massachusetts Bay, having been a few days previous at Nantucket and the Vineyard Sound. Nine-tenths of those first seen are males, and they are all large but poor, weighing from one pound to one pound and a half. At their first appearance they will not take the hook, and are therefore captured in seines."

The contrast between the statements of Storer and Captain Webb should be carefully noted. The former states that the early fish taken near the end of Cape Cod are mostly males. This would naturally be the case, as the females at this time are either engaged in spawning or are perhaps so weak that they would not be likely to come to the surface. At Milk Island, however, which seems to be in the middle of the spawning region, the majority of the fish are females.

We are indebted to Capt. N. E. Atwood for the most complete series of observations upon the spawning of the Mackerel which has ever been made, and what he has seen he shall be allowed to tell in his own words:

"I have many seasons been engaged in fishing for Mackerel in our bay with gill-nets. I watched the Mackerel more particularly in regard to their time for spawning. In 1856, owing to the fact that a measure had passed the Massachusetts legislature authorizing the appointment of three commissioners to make investigations with regard to the artificial propagation of the fish, and that I expected to be named one of the commissioners, I went to the upper part of Massachusetts Bay, where it is about twenty miles broad, and I found these spawning Mackerel there near the bottom. This year the Mackerel came in about the middle of May; few at first. On the 20th I went out for the first time with my drifting-nets all night in the bay; I caught 2,250 Mackerel; on the following night I caught 3,520. When I first began to catch them I observed that the spawn had come to its full size, though it was not free to run from them, not being yet fully matured. On or about the 1st of June we found that some of them were depositing spawn, and as I took them from the nets the spawn ran freely. On the 5th of June I took the mature eggs as they came from

the fish and put them in alcohol, marking the date, as I considered this time the middle of the spawning season. (By the 10th of June *the fish had all deposited their* spawn, and they then proceeded to the grounds where they expected to meet with better food in order to fatten and recruit. The spawning takes place at a depth of from five to fifteen fathoms.) Thirty days after I went out in the bay and found any quantity of schools of little Mackerel which were, I should *think*, about two inches long, though their length might have been a little less. I took a number of specimens and put them in alcohol, marking the date. Twenty-five days later I procured another lot of them which had grown to double that size. I don't mean to imply that they were twice as long, but twice as heavy. I put them also in alcohol, *marking the date. The first time I* subsequently went to Boston I called on Professor Agassiz and gave him the specimens. He said that he had never before been able to ascertain these facts so clearly and so well, and that he was very much pleased with them. I watched the growth of these young Mackerel all along, and I saw them *grow considerably from* month to month, so much so that the same fall, in the latter part of October, I caught some of them with a very small mesh net and found they had grown to a length of six and a half or seven inches. I kept a small quantity of them, split, salted, and packed them, in accordance with the Massachusetts inspection law, as No. 4's, and since Mackerel were then scarce and very high in price, I sold them for as much as $6 a barrel."

"Much yet remains to be learned in regard to the spawning season of the American Mackerel," writes Professor Baird, "and little more is known of this except in regard to the European variety. It is, however, well established by the researches of Sars that this fish, like the cod, and many of the flat fish, etc., spawns in the open sea, some times at a great distance from the land, at others closer inshore. Sars found them on the outer banks of the coast of Norway; and Mr. Matthias Dunn, of Mevagissey, England, communicates to 'Land and Water' his observations of Mackerel found, with ripe spawn, six miles from the coast.[1]

"The fish taken in the weirs and pounds on Vineyard Sound *and about Cape Cod in the early* spring are filled with ripe spawn; and that the operation of spawning takes place on the American coast is shown by the immense schools of small fish that are taken throughout the summer, of various sizes, from a few inches up, and from Buzzard's Bay to Portland and Penobscot Bay. No species *of young fish is*, at times, more abundant throughout the summer season than the Mackerel.

"The egg of the Mackerel is exceedingly minute, not larger than that of the alewife or gaspereau. It appears to be free from an adhesive envelope, such as pertains to the egg of the herring, and in consequence of which it agglutinates together, and adheres to gravel, the rocks, or the seaweed at the bottom. As with the egg of the cod, that of the Mackerel is provided with an oil globule, which makes it float nearly at the level of the surface."

I am indebted to Mr. Frederick W. True for an enumeration of the eggs in two Mackerel taken at Wood's Holl, Massachusetts, *in May, 1873; one of these* contained *363,107*, the other *393,887*.

SIR: I have been again fortunate in taking a Mackerel alive in the act of spawning, on the night of May 10, about six miles from land. A better specimen could not possibly be had, and the roe ran freely without assistance. I got a bucket of sea-water, and allowed the fish to spawn in it; for some time I had a difficulty in finding what became of it, as the globules would not reflect the light of the candle like *the pilchard spawn; but by running the water into* a clean bottle, and holding it to the light, I found them floating on the surface, but not so buoyant as the pilchard roe. In this state they continued for about half an hour, and then gradually sank to the bottom; but, unlike the pilchard spawn, they retained their vitality there for more than twelve hours. With the daylight the globules could scarcely be discerned by looking directly down into the water; but on holding it towards the light in a bottle they could be seen, with that healthy, bright silvery hue so peculiar to living ones, each marked with a dark spot in the center. Believing the pilchard spawn would have reached you, I did not send you any of these. As I sent that spawn by post, I suppose the bottle must have been broken in the post-bag.—MATTHIAS DUNN (Mevagissey, Cornwall, May 15, 1871), *Land and Water, May 20, 1871, p. 353.*

The only previous record of the number of eggs yielded by Mackerel is that made by Thomas Harmer, in 1764, and published in the "Philosophical Transactions" of London, vol. 57, p. 285. He found in one large Mackerel, weighing one and a quarter pounds, 454,961 eggs; in a second, of much the same weight, 430,846; and in a third, weighing about one pound two ounces, 546,681.[1]

RATE OF GROWTH AND SIZE.—The rate of growth of the Mackerel during the first summer has been quite carefully studied by Captain Atwood; and the same authority has, perhaps more satisfactorily than any other, interpreted the facts from which may be deduced the conclusions as to their growth year by year.

Referring to the small fish, six and a half or seven inches in length, which he believed to be the young of the year, caught by him in October, 1856, he says: "Fish of this size are sometimes called 'Spikes,' but I do not know their proper name. The next year I think they are the 'Blinks,' being one year old; the following year they are the 'Tinkers,' two years old, and the year after they return to us as the second-size, three years old. It is probable that the fish reaches its full maturity in four years." He continues: "The first Mackerel that come in are very large and spawners, but these do not bite at the hook; and you don't catch them with the seine, because they don't show themselves. You would not know of their presence if you did not set nets for them. When they are taken in nets set anywhere along the coast, at Provincetown, etc., a good many people imagine that they are the remnant of the Mackerel which were there the year before, and which have been imbedded in the mud; and when they taste these fish they fancy that they taste mud. When the next school arrives there appear Mackerel of different sizes, which take the hook. They are carried to Boston market and are sold fresh in their season. They are not sold by weight, but are culled, and are denominated as follows: Large ones, second-size, "Tinkers," and "Blinks." When the large ones are worth twelve cents, the others may sell, second-size, eight cents; Tinkers, four cents, and Blinks, one and a half cents. These prices may fluctuate when there occurs a large proportion of one or more of the above-named kinds at the same time. Any man who is well acquainted with them will make the same culling, as there seems to be a line of demarkation between the different kinds which stands out prominently.

"Admitting this to be the fact, those that come as Blinks are from the spawn of the year before, while those which are called "Tinkers" are from the Blinks of the year previous, being the two-year-old fish; and those that are called second-size are from the Tinkers of the year before; when they grow up and mix with the bigger ones, I don't know how they live, or much about them. This is my opinion about these matters. You will find that fishermen will tell you they think that Mackerel are six or seven years in getting their growth."

Mackerel, when full grown, are from seventeen to eighteen inches in length; sometimes they attain a larger size. In August, 1880, a school of Mackerel was taken in the vicinity of Plymouth; they weighed from three to three and a half pounds each, and were from nineteen to nineteen and a half inches long. They were regarded as extraordinarily large, and a barrel of them were sent to the Fishery Exhibition at Berlin as an illustration of the perfection to which the Mackerel attains in this country. Although the size just mentioned is unusual at present, in past years many thousands of barrels have been taken nearly, if not quite, as large. The size varies from year to year, sometimes very few barrels which can be rated as No. 1's being found in our waters.

No.	Date.	Weight.	Weight of spawn.	Number of eggs.	Number to a grain.
		Ounces.	*Grains.*		
1	June 20, 1764	20	1,027	454,961	443
2	June 29, 1764	20	949	430,846	454
3	June 18, 1765	18	1,223½	546,681	447

A No. 1 Mackerel, according to the Massachusetts inspection laws, measures thirteen inches from the tip of the snout to the crotch or fork of the caudal fin. The average length from year to year for the whole coast is probably not far from twelve inches in length, and a weight of twelve to sixteen ounces. The following quotations from writers of two centuries ago are interesting, since they show that large Mackerel were known to the early colonists of New England:

"The mackerel, of which there is choicefull plenty all summer long; in the spring they are ordinarily 18 inches long; afterwards there is none taken but what are smaller."[1]

"The Makarels are the baite for the Basse, & these have been chased into the shallow waters, where so many thousands have shott themselves a shore with the surfe of the Sea that whole hogges-heads have been taken up on the Sands; & for length they excell any of other parts: they have bin measured 18. & 19. inches in length and seaven breadth: & are taken with a drayee, (as boats use to pass to & froe at Sea on business,) in very greate quantities all along the Coaste.

"The Fish is good, salted; for store against the winter, as well as fresh, & to be accounted a good commodity."[2]

ENEMIES OF THE MACKEREL.—The gannet is one of the most destructive enemies of the Mackerel. These birds are often seen so heavily weighted with these fish that they are unable to rise on the approach of the vessel until they have disgorged from two to four good-sized Mackerel. This is so common an occurrence that there are but few fishermen who have not witnessed it.

Porpoises and whales may also be included in the list of enemies of the Mackerel. It is by no means an unusual sight on the fishing grounds to see hundreds of the former rushing and leaping among schools of Mackerel, scattering them in every direction.

The shark known to fishermen as the "mackerel shark" is one of the principal enemies of the Mackerel. I have often seen them chasing Mackerel, and, when jigging was practiced, it was a common occurrence for sharks to drive off a school from alongside of a vessel.

Dogfish often hover around the outside of large schools of Mackerel, and doubtless feed on them. Great difficulty is sometimes experienced in saving fish that have been inclosed in a purse-seine, owing to the immense numbers of dogfish that gather around and, in their efforts to eat the Mackerel, which they see through the meshes, bite off the twine, making large holes in the seine through which the inclosed fish escape.

Among the other principal enemies of the Mackerel are the bluefish, mackerel shark, and the cod. The appearance of a school of bluefish in waters crowded with Mackerel is an almost sure signal for their disappearance.

The young Mackerel are eaten by squids also. Professor Verrill has recorded the following account of the maneuvers of the squid known to zoologists by the name *Ommastrephes illecebrosus:*

"Messrs. S. I. Smith and Oscar Harger observed it at Provincetown, Massachusetts, among the wharves, in large numbers, July 28, engaged in capturing and devouring the young Mackerel, which were swimming about in 'schools,' and at that time were about four or five inches long. In attacking the Mackerel, they would suddenly dart backward among the fish with the velocity of an arrow and suddenly turn obliquely to the right or left and seize a fish, which was almost instantly killed by a bite in the back of the neck with the sharp beaks. The bite was always made in the same place, cutting out a triangular piece of flesh, and was deep enough to penetrate to the spinal cord. The attacks were not always successful, and were sometimes repeated a dozen times before one of these active and wary fishes could be caught. Sometimes after making several unsuccessful attempts one of the squids would suddenly drop to the bottom, and, resting upon the sand, would

[1] JOSSELYN, 1675.

[2] New England's Fish, JOHN SMITH, 1622. United States Fish Commission Report, Part I, p. 153.

change its color to that of the sand so perfectly as to be almost invisible. In this way it would wait until the fishes came back, and when they were swimming close to or over the ambuscade, the squid, by a sudden dart, would be pretty sure to secure a fish. Ordinarily when swimming they were thickly spotted with red and brown, but when darting among the Mackerel they appeared translucent and pale. The Mackerel, however, seemed to have learned that the shallow water is the safest for them and would hug the shore as closely as possible, so that in pursuing them many of the squids became stranded and perished by hundreds, for when they once touch the shore they begin to pump water from their siphons with great energy, and this usually forces them farther and farther up the beach. At such times they often discharge their ink in large quantities. The attacks on the young Mackerel were observed mostly at or near high water, for at other times the Mackerel were seldom seen, though the squids were seen swimming about at all hours; and these attacks were observed both in the day and evening."

The dogfish is doubtless a dangerous foe to the Mackerel weakened by the act of spawning and remaining near the bottom. An old fisherman has described to me with great animation how greedily the dogfish devour the Mackerel which have become gilled in the nets, how they follow them to the surface and linger about the vessel while the process of cleaning is going on, drinking the blood of the fish as it flows from the scuppers.

STUDIES OF THE MOVEMENTS OF THE MACKEREL SCHOOLS.

HIND ON THE CAUSES OF IRREGULAR MOVEMENTS.—In closing this chapter upon the natural history of the Mackerel, it seems appropriate to quote from the writings of Professor Hind some very important paragraphs in which he has attempted to interpret the irregular movements of the mackerel schools in our waters, and to explain the causes of the alleged annual variation of their numbers:

"What is the proper interpretation of the movements of the Mackerel from its first appearance in the spring to its disappearance in the fall? These movements vary with the geographical position of local schools of this fish. On the coasts of the United States and Nova Scotia, its annual movements resemble in all particulars those of the same species in European seas where the schools have a free and unobstructed ocean in which to seek their prey.

"In the spring, at the end of April and May, the Atlantic schools of this fish which have wintered off the coasts approach the land in separate bodies, full of spawn and poor, coming direct from winter homes where they have remained in a torpid condition, partially buried in sand or mud. After spawning, the different schools feed for a short time on the fry of fish, and as the temperature rises they go out to sea in search of free-swimming crustaceans and larval forms of food according as they are distributed by wind and tide.

"They pursue this food against the current or tide. They often feed during the night, because at that period great numbers of free-swimming larval forms approach the surface. This is one reason why mackerel schools are frequently missed by fishermen, and areas supposed to be deserted may really abound with this fish, which would be discovered by sink-net fishing. The currents are constantly changing with the seasons under the influence of temperature and prevailing winds, hence the course of direction and depth of the food is constantly changing also.

"Sometimes it is carried far off from the land, at other times towards it, and the mackerel schools following the food move first in one direction, then in another, and range from close inshore to fifty miles and more seawards, and often, doubtless, at a considerable depth below the surface.

"The general direction of these movements, when plotted on paper, would be a series of irregu-

lar circles or elongated ellipses, the range of each school or group of schools being opposite and often adjacent to that part of the coast where they spawn.

"As the fall approaches, owing to the diminution in the supply of their floating food out at sea, they come more inland.

"All the free-swimming larval forms of most species of shrimps, crabs, lobsters, sea-urchins, star-fish, sea-worms, &c., have disappeared in the open sea, after passing through their final transformation. But near the shore there are great numbers of other forms of life, which are developed later in the year. Coming inshore to feed on these on the Atlantic coast, the Mackerel are found by American fishermen later and later on their return voyage to the southwest, which gives rise to the impression that they are following the schools, when they are only meeting with fresh schools approaching the shore from their feeding grounds. Similar movements occur on the Atlantic coast of Nova Scotia and Cape Breton. As winter approaches, beginning at Cape Breton in November, the different schools retire to their winter homes off the coast in deep water later and later from north to south.

"In the Gulf of Saint Lawrence, where land is, as it were, on all sides, the local schools come from their winter haunts to the banks and beaches of the Magdalens, of Prince Edward Island, in the Bay Chaleur, etc., to spawn about the first week in June. They retire after spawning to deep water, and meet the incoming sand-launce. They follow the sand-launce inshore or on to banks, and for some weeks feed on these fish. When the sand-launce again retires to deep water, the season of the small crustaceans has arrived, and these by tidal action, already described, and winds, are concentrated near the coast lines of Prince Edward Island, New Brunswick, the north and south shore of the estuary and gulf of Saint Lawrence, and the shores of Cape Breton. On all these coasts the effect of the single and confluent tides, dragging along the coast line and retarded by it, is to produce eddies, where the free-swimming food concentrates. The course of direction of the different schools during the summer is thus dependent upon winds and tides, and their movements would, if correctly plotted, resemble long narrow ellipses adjacent to the coast, which are doubtless many times repeated.

"At the approach of winter the different schools seek their winter quarters opposite and near to the places where they spawned in the preceding spring, as is the case of the schools on the Atlantic coasts. In these particulars their movements resemble those of different species of fish which feed and move in great schools in directions outlined by circles or ellipses throughout the period during which they are at the surface.[1]

[1] It is a fact well known to all experienced mackerel fishermen that during the month of May and the early part of June large bodies of Mackerel pass along the shores of Nova Scotia and Cape Breton from west to east, and while many schools move through the waters of Chedabucto Bay and the Straits of Canso to the Gulf of Saint Lawrence, another body passes in around the east end of Cape Breton Island, their destination being the same as those fish taking the shorter route. No better evidence of this migratory habit can be deduced than the fact that at this season of the year the fishermen along the Nova Scotian coast and about the Strait of Canso are busily employed in catching Mackerel both in gill-nets and in drag-seines. On some occasions when the season has been exceptionally favorable the amount of Mackerel so taken has often been very great. This movement of the Mackerel is so regular and so well-defined that the fishermen rarely fail to tell within a few days, or perhaps even a few hours, of the time when they will appear on certain portions of the coast. The fall migrations are quite as regular. As the season advances and the temperature of the water decreases, the Mackerel, instead of simply changing their position into deeper water near their summer habitat, as has been stated by Professor Hind, move in vast bodies towards the southern part of the Gulf of Saint Lawrence, frequently striking in a succession of waves, as it were, on the northern shores of Cape Breton Island, where, deflected from their southern course, they divide into two streams or branches, one passing through the Strait of Canso, and the other out round the north cape of the island, and by its eastern and southern sides, and so on up along the south coast of Nova Scotia. The Mackerel which are found about the Magdalene Islands during the summer and early autumn apparently move in a nearly direct line towards the northeast end of Cape Breton Island, when they begin their fall migration. I have often had occasion to notice, in a practical way, these movements, the knowledge of which is of vital importance to the fishermen and of considerable interest to the

"Sars has shown that this form of movement is taken by the herring on the Norwegian coast.[1]

"The Mackerel are pursued by cod and hake, and these fish gather where offal is thrown over from vessels on which the Mackerel are cleaned. As a natural consequence the Mackerel avoid the sea areas where their enemies are congregated, and fishermen attribute the desertion of the mackerel ground *directly to the throwing of offal overboard. Cod, and probably hake, follow* up the scent of offal or food of any description carried by currents with remarkable facility, as may be witnessed during the process of jigging for cod in calm and clear waters. On looking over the side of a boat, with a man engaged in jigging at the bow or stern, as soon as a fish is wounded merely by the jigger and blood flows from the wound, the creature may be seen to dart here and there in pain. The neighboring fish of the cod tribe are attracted by the scent and follow the blood 'tracks' against the current, hunting their wounded comrade to the death. A fish coming across the stream of scent immediately follows it up, and it is thus that fish offal or bait thrown overboard in the open sea, or some distance from shore, gathers the fish on the course of the current. In harbors and confined or land-locked bays, where there is no constant strong current to *carry off the results of decomposition, and where the sea-scavengers are not sufficiently numerous* to consume it, the effect cannot fail to be extremely prejudicial to young fry and to fish-spawn.[2]

"The effect of temperature on the local movements of the Mackerel may be recognized in the process employed by fishermen to 'raise' Mackerel by toll bait, and luring them seawards. The Mackerel follow the bait for some distance from shore, where suddenly they cease to bite and disappear. They probably find long exposure to the warm temperature of the surface waters unsuited to their habits, and sink to a cooler zone.

"Hence the reason why a 'mackerel breeze,' mixing the heated surface water with the cooler understratum, is favorable to prolonged mackerel fishing with bait. The mixing produced by agitation cools the surface and permits the fish to feed for a lengthened period."[3]

"The Mackerel, like the herring and the cod, seeks cold water for its spawning grounds wherever the Labrador current exercises its influence. Between Block Island and No Man's

naturalist. On one occasion, in the fall of 1867, an immense body of Mackerel was found along the north shore of Cape Breton, and on the last day that the fish were seen the schools came near the surface of the water, and I feel safe in saying, from actual observation, that they moved at a rate of no less than three or four miles per hour in the direction of the north cape of the island. On another occasion, a body of Mackerel that was found near Amherst Island (one of the Magdalenes) one day, were met with the following morning about thirty miles distant from the first locality, in the direction of the north cape of Cape Breton Island, towards which they were moving at the rate of one or two miles an hour. I have myself seen schools of Mackerel off the Nova Scotian coast, in the fall, moving quite rapidly in a westerly direction, but all efforts to catch them with a hook failed, since they seemed to pay no regard whatever to toll bait. All of my own observations, and those of the Nova Scotian fishermen with whom I have been brought in contact, lead me to believe that Mackerel will not bite the hook to any extent during their fall migrations along the southern coasts of Nova Scotia. This is all the more remarkable since they seem to take the hook very eagerly up to the last moment of their stay on their feeding grounds in the gulf. The spring and fall migrations of the Mackerel on our own coast are carried on with equal regularity and precision. On more than one occasion, in autumn, I have followed these fish day after day in their progress to the south and west along the shores of Maine and Massachusetts. On one occasion, in the fall of 1862, I caught Mackerel nearly down to the fishing rip on the Nantucket *Shoals. These fish were moving rapidly southward, and the schools could be kept alongside of the vessel only a short* time, and each trial had to be made two or three miles farther south than the previous one. At another time, in the fall of 1870, the Mackerel moved in large schools very rapidly from Ipswich Bay across in the direction of Cape Cod. The schools were at the surface of the water, and it is not an exaggeration to say that their speed was not less than three or four miles an hour. Each body of fish was separated from the others, perhaps many hundred fathoms, but all seemed to be impelled by the same motive, and were moving steadily in the same direction. These fish would bite eagerly at the hook for a few minutes at a time, but so strong was their instinct of migration that it was impossible to detain them only a short time in their onward movement.—J. W. COLLINS.

[1] See chart by Dr. G. O. SARS, in his report for 1874.

[2] Fisheries of British North America, pp. 20, 21.

[3] Fisheries of British North America.

Land, where the spawning grounds on the United States coast south of Cape Cod are alleged to exist, a thin wedge of the Labrador current stretches far into Long Island Sound.

"In Massachusetts Bay, where a mackerel spawning ground also exists, as also in the vicinity of Stellwagen Bank, the temperature when observed by Dr. Packard in September ranged from 41½° to 45°, and the fauna resembled the cold-water species on each side of Jeffrey's Ledge. On George's Shoals the marine life is said by Verrill to be the same as that found in the deeper muddy parts of the Gulf of Saint Lawrence, and indicates a temperature not above 40°, and probably considerably lower. Bradelle Bank, according to Mr. Whiteaves, presents the phenomenon of a small stony patch tenanted by an assemblage of marine animals which usually inhabits very cold water, and are almost entirely surrounded by another series, which are for the most part prevalent where the bottom is warmer and more affected by surface conditions of temperature.

"Wherever the areas are situated where young Mackerel are found in the summer we find near at hand a cold-water zone, either existing as a part of the Labrador current at the surface or brought up from greater depths by banks and shoals. On the coast of Prince Edward Island, and in the gulf generally, the cold water lies frequently near the shore, because the diurnal tides mix the strata warmed during the daytime with the cold underlying strata. In the estuary of the Saint Lawrence Dr. Kelly found the surface temperature 57° F. on the 9th July, but three feet below the surface it was 44°, having in that short vertical space sunk 13°; at twenty-four feet it was 40°, or 17° below the surface temperature."

96. THE CHUB MACKEREL—SCOMBER COLIAS.

The Chub Mackerel, or, as it is also called, the "Thimble-eye," "Big-eyed Mackerel," or "Bull Mackerel," closely resembles in general appearance the common Mackerel, from which it is distinguished chiefly by the presence of an air-bladder, and also by the occurrence of a row of indistinct circular spots upon the sides below the lateral line. This is the fish which is called "Spanish Mackerel" in England, and the name was brought to us by the early English fishermen of New England. It has been found at Pensacola and Charleston, as well as in New England. There is another fish closely related if not identical with *S. colias*, which Professor Jordan found to be abundant in California, which corresponds to the *S. pneumatophorus* of the Mediterranean,[1] and has been described from the Pacific as *S. diego*. Professor Jordan considers this to be the *S. grex* of various authors, but writes that he is not yet prepared to accept as final the judgment of Steindachner and Vaillant that it is the young of *S. colias*. The lower half of its sides is silvery and without any gray spots, such as are conspicuous in *S. colias*. Jordan has specimens of the unspotted form much larger than his smallest specimens of the true *S. colias*.

The history of the Chub Mackerel on our coast is a peculiar one. At the beginning of the present century it was exceedingly abundant all along the coast of New England and New York. Mitchill, writing in 1814, remarked of it:

"Comes occasionally in prodigious numbers to the coast of New York in autumn. This was memorably the case in 1781 and 1813, when the bays, creeks, and coves were literally alive with them, and the markets full of them."

DeKay remarks: "In the early part of November, 1828, they were also very abundant, and many persons were poisoned by eating them."

Capt. Epes W. Merchant, of Gloucester, a veteran fishing skipper, who has been familiar with the fisheries of Massachusetts Bay for the past seventy years, told me that the Thimble-eye

[1] CANESTRINI: Fauna d' Italia. Pesci, 1872, p. 101.

were so abundant from 1814 to 1820 that with three men and a boy and a small vessel he could catch ten barrels of them, or about three thousand fish, in a day.

The "Fishermen's Memorial and Record Book," published in Gloucester, contains the following note:

"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, of from fifteen to twenty tons. These rooms held from fifteen to twenty barrels, and the crews would catch them full in a few hours. Mr. Timothy Rogers, at Rowe's Bank, bought most of these Mackerel, fresh, after being dressed, at two 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."

Captain Oakes states that the "Thimble-eye Mackerel," or "Mixed Mackerel," were very plentiful from 1826 to 1830. In 1826 he went fishing in the schooner "Delegate." The season's catch amounted to fifteen hundred barrels. Perhaps twenty-five barrels of these were "Thimble-eyes."

Capt. N. E. Atwood, of Provincetown, wrote, in 1878, that sixty years ago, when he was a boy, and many years afterwards, they were very abundant in Massachusetts Bay, but that he has not seen them for nearly thirty years. They went away before the bluefish returned, and before any weir, trap, pound, or any other engine of wholesale destruction was set in the New England waters.

Storer, writing in 1846, remarked: "This fish is of late years found more rarely along our coast than formerly. Captain Blanchard informs me that during some seasons but two or three individuals are taken by the fishermen. Captain Atwood has seen but a single specimen during the last four or five years. Many years ago it was abundant at Provincetown, and would run up the small creeks and be left by the tide."

J. V. C. Smith, in his "Natural History of the Fishes of Massachusetts," published in 1843, remarked that "they abound at New York, but for some reason make their appearance north of Cape Cod."

From these testimonies it would appear that between 1840 and 1850 the species, formerly so abundant, had disappeared along the whole coast line. In an essay by the writer, written in the spring of 1879, this sentence occurs: "For ten years past the Smithsonian Institution, with its collectors stationed at various points from Halifax to Galveston, has tried in vain to secure one of them, and it is probable that no museum in the world possesses a species of this fish, once so common."

In the summer of 1879, however, during the stay of the Fish Commission at Provincetown, a considerable school of these fish came into the harbor and were taken in company with the Tinker Mackerel. None were observed there in 1880, however, and it remains to be seen whether they have returned to be again counted among the permanent members of the fauna. This fish, during the period of its abundance on our coast, was considered an excellent article of food, and was by many preferred to the common Mackerel. On account of its small size, however, it was not so much sought after by the fishermen.

Concerning the Mackerel of the Pacific coast, which Professor Jordan considers to be identical with the *Scomber pneumatophorus* of the Eastern Atlantic, this authority writes:

"The Tinker Mackerel, *S. pneumatophorus*, is known as 'Mackerel,' 'Easter Mackerel,'

'Tinker Mackerel,' and 'Little Mackerel.' It reaches a length of about fourteen inches. It ranges northward to Monterey Bay, appearing in the fall in irregular and often large schools, usually disappearing in November. Some years few or none are seen. It is a good food-fish, but little attention is paid to it, on account of its small size and irregular occurrence."

The following account of the early discovery of Mackerel on the California coast appeared in the Gloucester "Telegraph" of July 20, 1870:

"Mackerel are reported quite abundant along the coast of California, but the people of that State have not learned to catch them, and continue to import their Mackerel from the Eastern States. Only one or two attempts have been made to avail themselves of a supply nearer home. In 1855 a few San Francisco fishermen made a trip to Santa Barbara Channel, in a small schooner, and soon filled her with Mackerel, but instead of cleaning them and soaking them out they threw them into salt without dressing, and when they arrived home their fish were, of course, in bad order. A more experienced captain in 1858 put up properly a hundred barrels of No. 2 Mackerel at Santa Barbara, which he disposed of at $16 per barrel. The San Francisco 'Bulletin' claims that enough can be caught there to supply the want of their market, while salt of the best quality for curing them can be got free from the neighboring salt-water lagoons. It says that the Mackerel abound there all the year round—which is probably incorrect—but that the months for taking them in the largest quantities are June, July, and August. 'If Mackerel are caught before June and after August,' says the 'Bulletin,' 'they are too poor to cure to advantage, and deserve the name of "leather-bellies." And if they are not cleaned and washed in salt water immediately after being caught, and before salting, they will spoil and become at least inferior food. But with necessary experience, skill, and judgment on the part of the fishermen, and the encouragement, enterprise, and outlay on the part of all interested in trade and the development of our home industries, there are Mackerel enough on our coast of the best quality to supply all the wants of our city and State.'"

97. THE FRIGATE MACKEREL—AUXIS THAZARD.

This species has also lately made its appearance in our waters, none having been observed before 1880, when they came in almost countless numbers. It is yet to be determined whether this species is to be a permanent accession to our fauna. It is the "Timberello" of the Adriatic fisher folk.

The United States Fish Commission obtained numerous specimens, twenty-eight barrels having been taken in a mackerel seine ten miles east of Block Island on August 3, 1880, by the schooner "American Eagle," Capt. Joshua Chase, of Provincetown, Massachusetts.

The Frigate Mackerel resembles, in some particulars, the common Mackerel; in others, the bonito, the genus *Auxis* being intermediate in its character between the *Scomber* and the related genera *Pelamys* and *Orcynus*. It has the two dorsal fins remote from each other as in *Scomber*, and the general form of the body is slender, like that of the Mackerel. The body is, however, somewhat stouter, and, instead of being covered with small scales of uniform size, has a corselet of larger scales under and behind the pectoral fins. Instead of the two small keels upon each side of the tail, which are so noticeable in the Mackerel, it has the single, more prominent keel of the bonito and the tunny. Its color is grayish-blue, something like that of the pollock, the belly being lighter than the back. Under the posterior part of the body, above the lateral line, are a few cloudings or maculations resembling those of the Mackerel. The occurrence of a large school of this beautiful species in our waters is very noteworthy, for the fish now for the first time observed are very possibly the precursors of numerous schools yet to follow. It is not many years

since the bonito became an inhabitant of our waters, and the distribution and habits of the Frigate Mackerel are supposed to be very similar to those of the bonito, *Sarda pelamys*, and the little tunny, *Orcynus thynnus*, which also first came on the coast in 1871, and have since been found in considerable numbers.

The Frigate Mackerel has been observed in the West Indies, and other parts of the tropical Atlantic, as well as on the coast of Europe. In Great Britain it is called the "Plain Bonito." It is not unusual in the Bermudas, where it is called the "Frigate Mackerel," a name not inappropriate for adoption in this country, since its general appearance is more like that of the Mackerel than the bonito, while in swiftness and strength it is more like the larger members of this family.

Since the first appearance of this fish many new observations of its abundance have been received. These fish appeared to come in immense schools into the waters between Montauk Point and George's Bank; and from Mr. Clark's statements it appears that they have been observed in small numbers by fishermen in previous years. Several vessels have come into Newport recently reporting their presence in immense numbers in the vicinity of Block Island. It will interest the "ichthyophagists" to know that several persons in Newport have tested the fish, and pronounce it inferior to the bonito. Part of the flesh, that on the posterior part of the body, is white, but behind the gills it is black and rank, while the meat near the backbone is said to be of disagreeable, sour flavor.

It is hard to predict what its influence will be upon other fishes already occupying our waters. Its mouth is small and its teeth feeble, so that it is hardly likely to become a ravager, like the bonito and the bluefish. There is little probability, on the other hand, that its advent will be of any special importance from an economical point of view, for its oil does not seem to be very abundant, and it will hardly pay at present to capture it solely for the purpose of using its flesh in the manufacture of fertilizers.

Mr. A. Howard Clark, at that time in charge of the Fish Commission station at Gloucester, communicated to Professor Baird interesting statements regarding its abundance. From these it would also appear that the species has been observed occasionally in past years. He wrote under date of August 10: "I have received this morning from the schooner 'Fitz J. Babson,' just arrived from Block Island, a fish answering to your description of the Auxis, having a corselet of scales around the pectoral fin, as in the tunny. The captain of the vessel, Joshua Riggs, reports that about a week ago we had a hundred barrels in the seine at one time, and saw over twenty schools of them. He saw them as far east as Sow-and-Pig light-ship. They are very easy to catch, flip like menhaden, do not rush, and are not frightened at the seine. They go in immense numbers—he thinks as many as one thousand barrels to a school. The day after the appearance of these fish the Mackerel disappeared, but he does not know whether the Mackerel were driven away by them or not. They feed on Mackerel food. Mr. Daniel Hiltz, of the same vessel, says that he caught one of just the same kind, in February, 1879, on a haddock trawl on the eastern part of the Middle Bank, in forty fathoms of water. He took it to Boston, where it was called a young bonito.

"Mr. John Henderson, of the schooner 'Sarah C. Wharf,' says that two vessels caught such fish recently eastward of here. The schooner 'American Eagle,' of Provincetown, took a number of barrels of them into Newport, and sold them for a dollar a barrel. Another Cape Cod vessel [he does not know her name] took about fifty barrels of them and threw them away. All the mackerel seiners from Block Island report seeing quantities of this new fish within the past fortnight. The captain of the schooner 'Sarah C. Wharf' says he first saw them a fortnight ago, some

fifteen miles off Block Island. The captain and several of the crew of the 'Ella M. Johnson,' of Newburyport, just arrived from Block Island, state they saw abundance of the Auxis, but did not know what it was until the reports came from you at Newport. They opened one and found in its stomach the ordinary red mackerel food. This crew differ with the crew of the schooner 'Fitz J. Babson' with regard to the ease of capturing them; think them rather difficult to take; say they flip like pogies, and do not rush like Mackerel. "They saw ten large schools of them on Saturday last, when some fifteen miles south of Block Island."

It is very important that any observations made upon this species in years to come should be reported to the United States Fish Commission. The length of those I have seen ranges from twelve to sixteen inches, and their weight from three-quarters of a pound to a pound and a half or more. Those sent to New York market were part of the lot taken by the schooner "American Eagle" and brought into Newport, whence they were shipped by Mr. Thompson, a fish-dealer of that place. It would require from eighty to one hundred of them to fill a barrel; so the estimate of Captain Riggs, that there are a thousand barrels in one of the schools, shows how exceedingly abundant they must be. The name "Frigate Mackerel," used in Bermuda, would seem to be the best name for use in this country, since the fish resemble the Mackerel more than they do the bonito or tunny.

Capt. N. E. Atwood, of Provincetown, Massachusetts, the veteran fisherman-ichthyologist, has examined the specimens, and is satisfied that they belong to the same species with a fish which he found abundant in the Azores in 1840, when, led by the reports of Cape Cod whalers, he went to these islands in search of the Mackerel, the mackerel fishing being poor at home. No Mackerel were found except the Frigate Mackerel.

98. THE SPANISH MACKEREL AND ITS ALLIES.

The genus *Scomberomorus*, until recently known to naturalists under the name *Cybium*, is represented upon our Atlantic coast by three species, and on the coast of California by one. Of the three eastern species the Spanish Mackerel, *S. maculatus*, is the most important, although the others grow to a larger size. The three species may be distinguished by the following characters:

The Spanish Mackerel, *Scomberomorus maculatus*, has the teeth somewhat conical and very pointed. It has seventeen dorsal spines and a black spot upon the first dorsal.

The Cero, *Scomberomorus caballa*, has fourteen dorsal spines and the first dorsal fin immaculate. The young fish have the sides of the body marked with roundish yellow spots, which disappear with age, and the lateral line is very sinuous upon the posterior portion of the body.

The Spotted Cero, or King Cero, *Scomberomorus regalis*, has seventeen dorsal spines, and upon the front of the first dorsal, which is white, is a spot of deep blue, which is prolonged far back upon the upper edge of the fin. The sides are marked with broken longitudinal bands with brown spots.

The Spanish Mackerel.—Scomberomorus maculatus.

The Spanish Mackerel is found along our coast from Cape Cod to the eastern part of the Gulf of Mexico, and has also been observed about Cuba and on the coast of Brazil. A few individuals have been seen north of Cape Cod. Storer records the capture of one at Lynn, July 24, 1841, and states that specimens were obtained at Provincetown in August, 1847, and by Captain Atwood, at Monhegan Island, off the coast of Maine. Although abundant in the Gulf of Mexico, the species is rarely seen on the coast of Eastern Florida.

The history of this species, like that of several others of the Mackerel tribe, is very interesting, since it shows that its abundance upon the coast has varied much during the past two cen-

turies. The early chronicles of the colonies do not refer to it under its present name, but it is possible that this was the "Speckled Hound-fish" mentioned by Josselyn in his "New England's Rarities Discovered," published in 1673. Josselyn wrote: "Of Blew-fish, or Hound-fish, two kinds, Speckled Hound-fish and Blew Hound-fish, called Horse-fish."

The "Blew Hound-fish" can have been nothing other than the common bluefish of our coast, and it is hard to imagine what fish, except the Spanish Mackerel, can have been described under the other name. No other allusion to the fish is found in literature before 1815, when the fish was described by Mitchill in his work on the fishes of New York, under the name *Scomber maculatus*. The biographical portion of his notice consisted of two sentences: "A fine and beautiful fish. Comes in July."

Even the publication of this description does not seem to have satisfied contemporary ichthyologists of the existence of such a fish, for some of them did not hesitate to express the opinion that Dr. Mitchill had been deceived by accidental differences of color at different seasons of the year, and that there were not so many varieties of Mackerel as he imagined.[1]

In an essay on the fishes of New York market, published in 1854, Professor Gill referred to the Spanish Mackerel as a species of slight importance.

In 1878 the quantity sold in the New York market cannot have fallen much below 300,000 pounds, with a retail value of $225,000, while large numbers were sent away to Baltimore and other cities. There is, however, need of caution in drawing inferences from market reports without at the same time keeping in mind the true history of the fisheries. It is possible that Spanish Mackerel abounded in our waters long before they began to appear in the markets. Even now the number taken by the use of hook and line is very small. They are caught chiefly in traps and weirs, which have come into use since 1845, and many fishermen have expressed their belief that of late they have been rapidly increasing.

Genio C. Scott wrote, in 1875: "My experience in trolling for Spanish Mackerel off the inlets of Fire Island has convinced me that the fish is as numerous as the bluefish, and more so than the striped bass, at certain seasons, and is found a little farther seaward than either of those fishes. Every year the shoals of Spanish Mackerel become more and more numerous, and more are taken, but never in sufficient numbers to reduce the average price below sixty cents per pound. The shoals which I saw when last trolling for them would have formed an area nearly five miles square, and still the most successful boat did not take more than a dozen in three days. They will not bite freely at any artificial lure, and though numbers came near leaping on the deck of our yacht, they treated our lures with an indifference which savored of perverseness."

Mr. J. M. K. Southwick states that the first Spanish Mackerel taken in the vicinity of Newport were found in the summer of 1857. No one knew what they were.

The Gloucester "Telegraph" of August 17, 1870, contains the following item: "At Newport the epicures are in ecstasies over the fact that Spanish Mackerel, the most delicious fish caught in the sea, are taken there now in seines. It is only by southerly winds that they are tempted so far north."[2]

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[1] SMITH, J. V. C.: Natural History of the Fishes of Massachusetts, 1843, p. 295.

[2] The Newport "Daily News," August 19, 1872, has this item:

"LARGE HAUL OF SPANISH MACKEREL.—Saturday, Arnold James & Co., of this city, caught 208 Spanish Mackerel, weighing 495 pounds. This is the largest haul of this kind of fish that has ever been taken at any one time by any of our Newport fishermen. They were caught in the West Bay, and subsequently sold to Messrs. Carry Brothers, of this city."

And two days later, August 21, the Providence "Press" chronicled a still more remarkable catch:

"Another haul of Spanish Mackerel was made yesterday. This time it was over four hundred fish, averaging about two and a half pounds each. They were sold to a dealer at twenty-five cents a pound."

Mr. R. E. Earll, who has studied the history of the species on the coast of New Jersey and the Southern States, writes as follows:

"Prior to 1850 almost nothing was known of the fish about Sandy Hook. This is shown by the fact that about this time Mr. Robert Lloyd, a fisherman of Seabright, was engaged in trolling for bluefish, having a contract with one of the hotels to take his entire catch. He secured quite a number of Spanish Mackerel (these being the first he had ever seen), which were carried with the bluefish to the hotel; but the proprietor knew nothing of their value, and even objected to taking them at the nominal price of twenty-five cents each.

"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 a boat; the fishing being best when the water was a little rough. They continued to increase in number, or at least came to be more generally noticed by the fishermen, until 1866, when they were quite plentiful, becoming most abundant between 1870 and 1875. During that period it is said that they were often nearly as plenty as the bluefish, 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 formerly eight to ten miles from land, where they remain beyond the reach of gill-nets and pound-nets.

"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, Virginia, 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 numbers have 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 may have no control, may cause a like variation in the future."

In 1879 the writer, in preparing an essay upon this fish, remarked: "Mitchill, when he described the *Scomber maculatus*, sixty-five years ago, summed up what he knew of its habits in a single sentence: 'Comes in July,' and the studies of later naturalists have added but little to this terse story."

Since that time the studies of Mr. Earll and Mr. Stearns have added so much to our knowledge of the life and history of this fish that it may be said that its habits are now about as well understood as those of any other species on our coast. Instead of weaving the facts which have lately been recorded into a compact narrative, the statements of different observers will be given as nearly as possible in their own words.

Mr. Earll thus discusses its movements along the Southern Atlantic coast:

"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° Fahrenheit, and seldom enter that which is colder than 65°.

"Off Charleston, South Carolina, 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 the first individuals are not seen till late in July,[1] and 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 Sandy Hook. In this northern region they remain till the middle of

[1] 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.*

With all deference to the author of this report, I am unwilling without further evidence to accept this identification as accurate.—G. B. G.

September, after which the number gradually diminishes, and by the first 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. When feeding they remain constantly among these fish, exhibiting great activity in the capture of their prey, rushing through the water with great speed, and often leaping into the air in long and graceful curves. This peculiar leap is characteristic of the species, and by it the fishermen are enabled to distinguish the Mackerel from their allies, the bluefish, that, after jumping from the water, fall back upon its surface with a splash, instead of cutting it, as is the case with the Mackerel.

"During the spawning season the Mackerel enter the warmer and shoaler water of the bays, the individuals at this time being more generally disturbed 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, Maryland, 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, while no rivers of importance occur along the eastern shore, and the water 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."

Concerning its migrations in the Gulf Stearns writes: "The Spanish Mackerel is extremely abundant on the West Florida coast. They are first seen in March or April, four or five miles from land, moving along swiftly towards the westward, or playing at the surface with no apparent aim or course of movement. The time of their arrival is not certainly known, but they are quite sure to appear some time between the first of March and the last of April. One season, 1877, schools were seen off the coast in February, and the 'run' continued as late that year as usual. It is not an unusual habit for these early schools to remain at sea several weeks before approaching the land. During the latter part of April the first schools are seen coming into the Pensacola Bay, and from this time on through the summer they are continually passing in. I do not think the tide influences their movements, as far as entering or leaving the harbor is concerned, for I have seen them swimming against and with the tide. They move at the surface of the water, frequently jumping from it and splashing conspicuously. By this commotion are attracted many sea-birds, which learn that there is food for them in the shape of fragments of small fishes upon which the Mackerel prey. The individuals that make up the schools vary considerably in size; as a rule, the first to arrive are the largest fish, and measure from twenty to twenty-four inches, while those coming later measure only about fourteen or fifteen inches. Specimens of thirty-six and forty inches are sometimes caught by the use of trolling-lines, but these large fish are rarely found in the schools. Their abundance varies with different years, although not to so great an extent as some other migratory

species. The first few weeks they spend in the bays. They continue playing at the surface, preying on such schools of small fish or fry as may be present, but at the commencement of July they are less frequently seen, and after another space of two or three weeks are not seen at all, unless caught by trolling-lines at sea, or when a solitary individual leaps from the water in some remote place. There is a great difference in the movements of the fish which are ready to spawn and those which have finished spawning: the former keep away from the shore, playing at the surface with no apparent aim, while the latter swim in shoal water near the shore, underneath the surface, shaping their course with all possible directness for the harbor mouth. The school, as it moves along, resembles a compact mass of reddish-brown sea-weed. Santa Rosa Island seems to possess attractive features for the Spanish Mackerel, for they are very abundant there. This is a convenient station from which to watch their movements, on account of its narrowness and length. In August, September, and October small schools of Mackerel are seen following the shore along to the sea, and on reaching it they are lost to view in deep water. Many, probably, follow the deep water out of the harbor and are not seen at all, but enough are under observation to signify when they are 'running' and when the majority are gone."

As has already been remarked, the Spanish Mackerel is but rarely seen on the east coast of Florida, though abundant in the Gulf of Mexico. I have never seen one in this region, though the fishermen assure me that a few have been caught, and that small ones are occasionally taken on the bar at the mouth of the Saint John's River. Melton & Co., of Jacksonville, received a quantity from Cedar Keys in 1876, and they were exposed for sale in the city markets, where, however, they met with no purchasers. In the Indian River region there is a fish called there the Spanish Mackerel; it perhaps is the Spanish Mackerel, or one of the allied species.

Holbrook wrote in 1860: "But little is known of the habits of this fish; it seems, however, more solitary than the fishes of this family generally are, as it seldom happens that more than four or five are taken at the same time. It appears on the coast of Carolina in April and May, but is rarely seen during the summer months. It feeds on various species of small fish."

Dr. Yarrow wrote in 1873 of this species, as observed in the vicinity of Fort Macon, North Carolina: "They are abundant in the latter part of August and September, and are frequently found with the bluefish. A favorite locality is near the southern point of Shackelford Banks, where it is taken with nets and by hook; a great many are also taken near Cape Lookout in September in gill-nets. Is highly esteemed as food, but is not often eaten fresh, being generally salted. Size from ten to thirty inches."

Mr. A. N. Simpson stated in 1874 that the species was caught in small quantities in the shoals near Cape Hatteras, though seldom seen in the sounds.

Dr. Wilkins, of Hunger's Wharf, observed in 1880 that the average weight in that vicinity is from two to three pounds. They arrive about the first of June, and leave about the first of September. Twenty-five years ago it was a very rare occurrence to catch a Mackerel in the Chesapeake Bay, but now they are very plenty.

Mr. C. R. Moore, of Johnsontown, Virginia, wrote in 1874: "Spanish Mackerel come in September and October and stay until frost. They are most numerous about the mouth of the York River, where a large number are caught in seines and salted. They bring about $40 a barrel."

Professor Baird, who was one of the first to speak of the abundance of this species and to testify to its excellent qualities, wrote in 1854: "But two specimens were taken during my stay at Beasley's Point, and the species is scarcely known to the fishermen. It was more abundant at Greenport, Long Island; in the Peconic Bay, towards Riverhead, four hundred were caught at one haul of the seine. The flesh is excellent, having much the flavor of true Mackerel, only a little

richer and softer. The fish bring a high price in the New York market, where it has been but recently sold at from fifty cents to one dollar a pound, the prices varying with the season. It has been more abundant off our coast than ever before, and in the lower part of the Potomac numbers have been taken and salted down. They may frequently be found in this state in the Washington market, and readily recognized by the round yellow spots on the sides, and also by the size, which is so much larger than that of the common Mackerel."

DeKay, in 1842, mentioned that he had seen this species, taken in the seine, in the New York market, in August and September, nearly two feet long, but that they were not common.

REPRODUTION.—The breeding habits of this fish were never understood until the spring of 1880, when, to everybody's astonishment, it was found by Mr. Earll that one of the principal spawning grounds was in the Chesapeake Bay.

I quote in full the remarks of Mr. Earll upon their reproductive habits:

"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.[1] Professor Goode, in his 'Game Fishes,' had ventured the assertion that they probably spawned in midwinter, in the Gulf of Mexico and about the West Indies. These were, as far as we knew, 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 in midsummer. The investigations of the southern fisheries began in Florida in January, 1880, and when the fisheries in that region 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, forty 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 investigations, 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, varied 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 70° 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

[1] 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 batch."—Angling in American Waters.

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 whitefish 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 eighteen and a half 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 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 1,5 .6 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 whitefish, though it is much less so than many of the gadoids, a seventy-five-pound codfish yielding fully 9,000,000.

"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 fertilization, 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 very small and 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 thirty-two 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 uppermost. 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.

"Little 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, Virginia, who, in a letter dated Norfolk, Virginia, 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 four to six 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."

The observations of Mr. Stearns, recorded also in 1880, are exceedingly interesting as confirming and supplementing those of Mr. Earll:

"When the Spanish Mackerel first appear, late in March and early in April, they contain spawn in the half-developed state. By July this has become quite full, and it is believed by the most intelligent fishermen that when they disappear from sight at that time they do so for the purpose of spawning, and that the spawning-grounds are in the quiet bayous and lagoons, the places where the old fish are last seen. These views of the fishermen are partly conjectural, and at first I did not agree with them, but the more I observed the movements of the fish the more plausible seemed the fishermen's views. The following facts have led me to adopt them: (1) The Spanish Mackerel arrive in the spring with spawn and milt and go away without them. (2) They disappear into out-of-the-way places with nearly ripe spawn, and in a short time reappear in or about the same places without it. The operation of spawning leaves them somewhat emaciated. They do not, of course, spawn all at one time, and it is not unfrequent that fish with spawn and those which have deposited it are caught by a fishing-crew on the same day."

The Spanish Mackerel sometimes attains the weight of eight or nine pounds, though it rarely exceeds three or four pounds. A specimen taken off Block Island, July 8, 1874, the first of the season, measured twenty-six and one-fourth inches and weighed three pounds and five ounces. It is said to be the largest ever taken in this section, and was a female with the ovary spent. Those taken on the coast of New Jersey and farther to the eastward are considered much more delicately flavored than the Chesapeake fish, and command a higher price in the market. In the Gulf States, according to Mr. Stearns, the Spanish Mackerel are in great demand, though but few are caught in the Gulf of Mexico, on account of the absence of proper nets.

This species was ascertained by Professor Jordan to occur abundantly in the Gulf of California, and south as far as Mexico. It is for some reason not highly valued by the Mexicans.

The Cero or King-fish—Scomberomorus caballa.

The Cero is a West Indian species which has been recorded from Santo Domingo, Jamaica, Cuba, Martinique, Porto Rico, and Brazil. A few specimens have been observed as far north as Wood's Holl, Massachusetts. It is a magnificent fish. It often grows to twenty-five pounds, and sometimes, it is said, to one hundred pounds in weight. Its habits are probably not unlike those of the Spanish Mackerel. The name Cero is commonly accepted in the United States; it is a corruption of the Spanish *sierra*, and the Mexicans call the fish by that name.

"The King-fish," writes Mr. Stearns, "are very abundant in the southern part of the Gulf and common at some places in its northern portion. They live altogether at sea and are caught with trolling-lines. At Key West they are important as food-fishes, large quantities being sold in the markets. Two men in a small sail-boat sometimes catch more than a hundred in a day, and I have seen the market so glutted with them that five cents would buy one of the largest size."

Professor Jordan states that they are regularly caught with trolling hooks by nearly every steamer from Savannah to New York.[1]

The King Cero or Spotted Cero—Scomberomorus regalis.

The King Cero of the Florida Keys grows to be five or six feet long and to twenty or thirty pounds in weight. This fish also occasionally wanders as far north as the southern shores of Cape Cod in summer. It is abundant in the West Indies, having been recorded from Cuba, Santo Domingo, Jamaica, and Barbadoes. Cuvier, moreover, had a specimen from Brazil. It is more than likely that this and the preceding species are both included by the Key West fishermen under the name "King-fish," the differences in general appearance being so slight that it is hardly likely that they would be noticed by ordinary observers.

The Monterey Mackerel—Scomberomorus concolor.

The Pacific species may be called the Monterey Mackerel. It attains a length of about thirty inches and a weight of about five or eight pounds. It has only been seen in the Monterey Bay, where from five to forty individuals are taken every fall, most of them at Soquel. They appear in September and disappear perhaps in November. Nothing further is known of their distribution or habits. They always bring a very high price in the market (30 to 50 cents per pound), the flesh being similar to that of the Spanish Mackerel of the East, which species this fish closely resembles.

99. THE BONITO—SARDA MEDITERRANEA.

This fish is one of those which appear to live for the most part in the open ocean, wandering hither and thither in large schools, preying upon other pelagic fishes, and approaching land only when attracted by abundance of acceptable food. Several of the smaller species of the group of Tunnies, to which it belongs, are known to sailors by the same name. The common Bonito of England, *Orcynus pelamys*, is what is here called the "Striped Bonito," two or three specimens

[1] A RARE FISH.—Captain Matthews, of the steamer "Oriental," who arrived Tuesday from Savannah, brought home a fine specimen of the King-fish, which was caught in the Gulf Stream on the passage. It was placed on exhibition in the Quincy market, at stalls 127 and 129, and attracted considerable attention from the fact that it is the first one of the kind ever seen here. It weighs about forty pounds, and more nearly resembles the Spanish Mackerel in color and form than any other fish usually seen in this market, although it is much larger. It is a very fat, handsome fish, and is said to be a nice article for food.—Boston Journal, July 26, 1871.

of which have been detected in our waters since 1876, but the fish which most frequently and in greatest numbers approaches our shores is the one which is named at the head of this section. Almost nothing is known of its habits, and it is even impossible to define its geographical range with any degree of certainty, its distribution being quite unlike that of any other fish with which we are acquainted. It may be said, however, that it is found only in the Atlantic Ocean. On our coast it is found in summer between Cape May and Cape Sable, though rarely north of Cape Ann;[1] occasionally off Cape Hatteras and the mouth of the Chesapeake and in the Gulf of Mexico. Specimens have been taken about the Canaries and Madeira, at the Cape of Good Hope and in the Mediterranean. It has not been observed on the coast of Europe north of Gibraltar, nor at the Bermudas.

This fish does not appear to have been abundant in former years: it attracted but little attention in our waters before 1860, although it was alluded to in 1815 by Mitchill, in 1842 by DeKay, and in 1856 by Gill; none of these authors, however, seem to have regarded it as at all abundant.[2]

A note from Prof. J. Hammond Trumbull states: "This fish used to be quite common, in some years, in the Stonington market. I have a note of a considerable number in market July 22, 1842, their first appearance for the season."

Storer remarked in 1846: "This species, called by the fishermen in Boston market the 'Skipjack,' and by those at the extremity of Cape Cod the 'Bonito,' is very rarely met with in Massachusetts Bay. It is occasionally taken at Provincetown, and even at Lynn. At some seasons it is frequently caught at Martha's Vineyard with trailing bait."

During the past ten or fifteen years they have become exceedingly abundant about Block Island and the eastern end of Long Island.[3] Fabulous quantities are taken in the pound-nets.

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[1] August 6, 1876, Captain Webb, of Milk Island, took seventy-three Bonitos in his weir, and August 7 twenty-eight more in an eight-inch gill-net.

[2] The following extracts from the journal of one of the earliest settlers of New England may refer either to this fish or to one of the smaller species of Tunny:

"1635, JULY 18 [near Newfoundland]. Saturday, wind northwest, a fair, cool day. We saw this morning a great many of Bonitoes leaping and playing about the ship. Bonito is a fish somewhat bigger than a cod, but less than a porpoise."—Mather's Journal. Young's Chronicles of the First Planters of Massachusetts Bay Colony. Boston: 1846, p. 464.

"1635, JULY 21 [near Newfoundland]. Tuesday morning, a great calm after a hot night. This morning our seamen took a Bonito and opened him upon the deck; of which, being dressed, our master sent Mathew Michel and me part, as good fish in eating as could be desired. About noon the wind became northeast, good for our purpose, so that we went that afternoon nine or ten leagues a watch."—Mather's Journal. Young's Chronicles of the First Planters of Massachusetts Bay Colony. Boston: 1846, p. 464.

[3] BONITA.—We did not say half enough the other day about the new visitor in our bay, the Bonita. If it shall become plentiful in our waters, as it promises to be, it will become a most valuable article of food. A correspondent, whose opinion upon matters of this kind is ultimate, writes: "Your article on the Bonita is every word true; pray, have your attention turned to fish, the great question (economical) of the day. Last night I had a fish on my table which they said was a kind of Spanish mackerel; the moment I tasted it I said it was a Bonita, having eaten it thirty years since, on my first voyage to India, and the taste had never been forgotten. It is the salmon of the sea. Mark its solidity of flesh, its great weight, its purity of taste, entire absence of the slightly decayed taste all fish has during warm weather. It is as nourishing as beef." The remainder of the note is "strictly confidential," and so was the basket which accompanied it with the choicest treasure of the sea covered with the greenest leaves of the land. We certify from actual experiment that Bonita is the worthy rival of the Spanish mackerel, the sheepshead, and the salmon. We are pleased to quote it in our household market report at the more reasonable price of twenty cents a pound.—Providence Journal, July, 1871.

The people of Rhode Island are happy in consequence of the appearance in their waters of that excellent fish, the Bonita. This fish is esteemed superior to the Spanish mackerel, and nearly equal in flavor to the salmon. It has not been known in Rhode Island waters until recently; now it is so plentiful that it is sold in the Providence fish markets at twenty cents per pound.—Germantown Telegraph, August 2, 1871.

THE BONITA.—Mr. John Flynn, of the Citizens' Market, yesterday received another supply of that new and dainty fish, the Bonita, and those who have not yet tasted of this worthy rival of the Spanish mackerel, the sheepshead, and the salmon, will do well to call at his market to-day and obtain one of these rare visitors.—Providence Journal, 1871.

In 1877 four smacks were constantly running between Block Island and New York, carrying each from 4,000 to 8,000 Bonitoes a week, or perhaps 20,000 pounds. The yield of Block Island alone that summer was probably not less than 2,000,000 pounds. In one haul of the purse-seine by the schooner "Lilian," of Noank, 1,500 were taken; and in August, 1874, 1,200 in one pound-net.

They seem first to have attracted the attention of New England authorities about 1865. Genio C. Scott, writing in 1875, remarked: "His first arrival along our beaches and in our bays was about eight years ago, and his shoals have increased remarkably fast ever since his advent. As a table luxury it ranks, with epicures, below the striped bass and bluefish, but, because of its comparative rarity, it commands a price rather above either. The numbers of this fish annually taken about the approaches to our harbors with the troll and in nets has increased so much that it bids fair to become nearly as numerous as the bluefish."

HABITS, &c.—In habits the Bonito has much in common with the blue-fish, though it is, if possible, even more active and more the embodiment of perpetual and insatiable hunger. They come to and go from the coast together, and are often taken together in the nets. Sometimes two lines in one boat will fasten at the same time a bluefish and a Bonito. The Bonito, like the bluefish, appear to be attracted to our waters by the great schools of mackerel and menhaden, upon which they feed. The Bonito schools create much confusion as they pass through the water, and their progress is marked by flocks of screaming gulls and terns, which follow them to prey upon the remnants of their feasts. At the end of summer they disappear entirely. No very young Bonitos have been found in our waters. Genio C. Scott, however, records the capture of one in Jamaica Bay in 1874, weighing less than a pound, and which he believes to have been hatched the previous year. The Fish Commission also has one of the same size taken off Southern New England. Charles Potter, of Norwalk, Connecticut, states that small specimens, six inches in length, were from 1870 to 1874 frequently taken late in the fall in the weirs at Fisher's Island.

SIZE.—A fish weighing ten pounds measures twenty-eight to twenty-nine inches; eight pounds, twenty-seven to twenty-eight inches; seven pounds, twenty-six to twenty-seven inches; six pounds, twenty-five to twenty-six inches; four pounds, twenty-two to twenty-three inches. There have not yet been found in the adults any traces of mature spawn, though one taken off Norwalk, July 23, 1874, had the eggs well formed though not nearly mature.

THE FISHERY.—In 1875 the earliest Bonito was taken in the Robinson's Hole weir July 7, and two more came along July 24. They were not abundant until August, when many more were taken in Vineyard Sound by Oak Bluffs boats, trolling. The fishermen then believed that they were gradually increasing in numbers and importance and taking the place of the squeteague which were dying out. August 7 the weir at Cedar Tree Neck had taken nothing but Bonitoes, while those farther west at Menemsha Bight had taken only squeteague.

Bonitos are caught in the vicinity of Block Island with trolling-hooks. They bite sharply, like bluefish. The best bait is an ordinary bluefish hook with a petticoat of red and white flannel, though the fish will also take any bluefish lure.

On the eastern shore of Virginia Bonito are caught by harpooning, says Mr. C. R. Moore, and also with the hook. They are most numerous about the mouth of the York River. They come in in June and leave in September. It is quite possible, however, that the Bonito referred to by Mr. Moore is quite another fish—the Cobia, *Elacate atlantica*.

USES.—Tested side by side with the bluefish, at the same table, the Bonito seems not much inferior, though the flesh is somewhat softer and more perishable.

The Bonito may be ranked among the many excellent food-fishes of our coast, and, in any

country not so abundantly supplied with finely-flavored fishes, it would be considered of the highest value. Their vitality is so great and their supply of blood so abundant that unless bled immediately after capture their flesh, especially in warm weather, is apt to deteriorate. Great quantities of them are taken to New York, and there, as well as in Rhode Island and Connecticut, they are sold extensively under the name of "Spanish mackerel," at prices ranging from thirty five to fifty cents a pound. This was the common practice in 1874, and has continued since. The statement made by Scott in 1875, viz, that on account of their rarity they were preferred to the bluefish and striped bass, would not now be true; his prediction that they would in time become as abundant as the bluefish seems, however, during some years to have been almost verified. The dealers, by the change of name in the market above referred to, are able to obtain a high price for a fish which, under its own name, would be looked upon with suspicion. An absurd report that the Bonito was poisonous was current in 1874, probably owing to the fact that similar fish taken in warm climates are sometimes deleterious.

In 1874 the ordinary price in New York was one cent apiece, though in the wholesale markets they commanded the same price as bluefish, and many were sold, as has been stated, at the high rates of Spanish mackerel. The market was so glutted that many of the vessels could not dispose of their cargoes.

According to Stearns, our Bonito occurs also in the Gulf of Mexico, where it is everywhere abundant, and is found in the bays on the Florida coast. It usually moves, according to the same authority, at the surface of the water in small schools. At sea it is found throughout the year, and along the shore only in the summer. Small schools are sometimes taken in drag-seines in shallow water. Its market value at Pensacola is not great, although it has become an article of food.

THE PACIFIC BONITO.—On the California coast occurs a closely related species, *Sarda chilensis*, which is thus described by Professor Jordan:

"This fish is everywhere known as the Bonito. The names 'Spanish Mackerel,' 'Skipjack,' and 'Tuna' are also sometimes applied to it. It reaches an average weight of about twelve pounds, but the body is considerably longer and more slender than that of an Albicore of the same weight. It ranges from San Francisco southward to Chili, being abundant in Monterey Bay and about the Santa Barbara Islands in the summer and fall. It approaches to within half a mile of the shore, where, in company with the barracuda, it is taken in great numbers by trolling. It spawns in August or September. Its arrival is in early summer and its departure in the fall, at which season the young are said to be found abundantly in the kelp. It feeds chiefly on anchovies and squids. As a food-fish it is not held in high esteem, the flesh being coarse. Great numbers are salted and dried, and are in that state considered far inferior to the barracuda and yellow-tail."

THE STRIPED BONITO.—The Striped Bonito, already mentioned, is distinguished from other species by the presence of four dark lines, which begin at the pectoral fin and run along the side of the belly to the tail, the sides of the common Bonito being of a silvery white. This species, the Striped Bonito, is occasionally taken on the European coast, but rarely entering the Mediterranean. It is found in the Pacific on the coast of China and Japan, and is the species most commonly known to mariners as the Bonito, or Albicore, of the activity and voracity of which, as observed from the decks of vessels at sea, so many descriptions have been written. The first individual noticed on our coast was taken by Mr. J. H. Blake at Provincetown in July, 1877. Others have since been observed at Wood's Holl and in the New York markets.

One of the American men-of-war of Revolutionary times was named "Bonetta," after the fishes of this group.

THE LITTLE TUNNIES.—In addition to the Striped Bonito, which is, properly, a Tunny, there are two other small Tunnies—the Long-finned Tunny, *Orcynus alalonga*, and the Silver-spotted Tunny, *Orcynus argentivittatus*—which have since 1877 been added to the fauna of the United States.

The former of these two occurs in considerable abundance on the coast of California, and is there also known as the Albicore. Concerning it Professor Jordan writes: "This fish reaches a weight of about twelve pounds, and is much shorter and deeper than the Bonito of the Pacific. It is found from San Francisco southward, but is abundant only in the channels about the Santa Barbara Islands. It seldom comes within six miles of the shore, and it is taken by trolling. It spawns about the middle of August, its arrival on the coast being determined by the spawning season. It usually is present in June and July and disappears in the fall. It feeds chiefly on anchovies and squid, and various deep-water fishes (*Merlucius*, *Sudis*, *Myctophum*) are found in its stomach. As a food-fish it is even less valued than the Bonito, rarely selling for more than twenty to twenty-five cents. It is abundant, but of little economic importance, being usually fished for by sportsmen."

100. THE HORSE MACKEREL, TUNNY, OR ALBICORE.

The most important of the Tunnies is the so-called Horse Mackerel, or Albicore, *Orcynus thynnus*, the "Ton" or "Tuna" of the Mediterranean, and the "Tunny" of English-speaking people.

The distribution of this fish corresponds more closely with that of the ordinary species of the Atlantic, since it occurs not only in the Mediterranean and the Western Atlantic north to the Gulf of Saint Lawrence, but also on the coast of Europe to the Loffoden Islands, latitude 69°.

The following account of this species is for the most part from the notes of Professor Baird:

Of this fish, as found in American waters, our naturalists have not much to say, the species, although abundant at certain seasons of the year off particular parts of the coast, being not a very familiar one to our writers. They seem to be rather a northern fish, and are said by Storer to make their first appearance on our shores about Provincetown early in June, remaining until October. Of late years they seem to be increasing in abundance northward, becoming more and more common during the summer season at Newfoundland.

In 1878, Capt. Henry Webb, of Milk Island, near Gloucester, harpooned and killed thirty of these monsters, weighing in the aggregate at least thirty thousand pounds. They had entered his pound in pursuit of small fish, cutting without difficulty through the netting. One had his stomach full of small mackerel.

According to Captain Atwood, on their first appearance in Massachusetts Bay they are very poor, but by the beginning of September become quite fat and are very much hunted for the oil, the head and belly especially furnishing sometimes as many as twenty gallons. They are harpooned on the surface of the water, much like the Sword-fish.

The early traditions of this fish in Massachusetts Bay speak of them as being sometimes so tame as to take food from the hand; but they have long since given up this engaging habit. Their flesh is not esteemed in the United States, being rarely, if ever, eaten, although much used for mackerel bait. It is, however, more in favor in the Provinces. This species attains a very great size. One specimen, taken in 1838 off Cape Ann, measured, according to Dr. Storer, fifteen feet in length, and weighed one thousand pounds, while still larger individuals than this are on record.

Their food while in our waters consists, it is said, mainly of menhaden, of which they destroy a vast number. Their inclosure in the fishermen's nets is not much desired, as they are apt to

become entangled in them and to do much injury in their efforts to escape. They are pursued by the killer whales, before which they flee in great terror.

Strange to say, although highly prized in the Old World from the time of the ancient Romans to the present day, they are seldom, if ever, used for food in this country. Although occurring in large numbers and of remarkable size, no effort is made toward their capture; and though not unfrequently taken in weirs and pounds along the coast, they are always allowed to rot on the shore. Occasionally a portion of the flesh may be used as food for chickens, but seldom, if ever, for human consumption.

In the Mediterranean the Tunny is taken in large nets, known as *madragues* similar in many respects to the so-called "traps" of Seconnet River in Rhode Island. The fish are used partly fresh and partly salted, and they are put up in oil to a considerable extent and largely consumed in all the Latin countries of Europe. Considerable quantities are salted and canned, and canned Tunny of European manufacture is imported to New York in small quantities. The flesh is dark and not usually attractive, although wholesome. They appears to attain a greater size in America than in Europe, one of five hundred pounds in the Mediterranean being considered rather a monster, while in America their weight is not unfrequently given at from twelve to fifteen hundred pounds.

Nothing definite is known in regard to their mode of reproduction. The eggs are said to be deposited early in June, and the young at hatching, according to Yarrell, weigh an ounce and a half, reaching a weight of four ounces by August, and thirty ounces by October.[1]

Mr. Matthew Jones, of Halifax, Nova Scotia, writes: "The Tunny is very common on the eastern coast of Nova Scotia in summer, and is known to fishermen and others as the 'Albicore.' The Rev. J. Ambrose informs me that it regularly visits St. Margaret's Bay every summer, several specimens being taken and rendered down for oil. They were particularly abundant in 1876. They are never seen in the Basin of Minas."

Captain Atwood contributes the following note on Horse-Mackerel in Cape Cod Bay:

"They don't come till the weather gets warm. We don't see them at first when we begin setting mackerel nets, but about June they are liable to appear, and we find holes in the nets. Sometimes in September they gill them for the sake of their oil. My brother had forty-seven holes through one eighty-yard net in one night. When they strike a net they go right through it, and when they go through it the hole immediately becomes round. It looks as if you could put a half bushel through it. I said in my Lowell Institute lectures that a shark in going through a net would roll himself up in it, but the Horse-Mackerel get right through, and the hole that they cut could be mended in five minutes. The fishermen don't dread them much because they do the nets so little injury. They remain with us through the summer and early autumn, when they are killed for the oil. When they are here they feed upon any small fish, and when menhaden were here I have seen them drive the harbor full of them. I have seen the Horse-Mackerel swallow dogfish whole weighing eight pounds. As fast as we got out the livers of the dogfish they would catch them and eat them. There was a great deal of whiting here at that time. They have almost totally disappeared. The Horse-Mackerel seems to be the enemy of all kinds of fish. There

[1] *Orcynus thynnus.*—According to Dr. Fortin, the Horse-Mackerel is quite abundant in the Gulf of Saint Lawrence, especially in the bay of Chaleur and of Gaspé, and also in the Straits of Belle Isle and Blanes Sablon Bay. It is taken in increasing numbers in the Gulf, partly by spearing and partly by baiting. For this latter purpose strong steel hooks are used tied to solid lines and baited with herring. This fishing is prosecuted more particularly in the Bay of Chaleur and off Caraquette, where in 1863 over one hundred were captured. The fishing is quite exciting, although tiresome and requiring a good deal of skill, as in the efforts of the fishes to escape they pull with such violence as to endanger the lives of the fishermen by dragging them overboard.—Canadian Fishery Report for 1863, 62.

is nothing to trouble the Horse-Mackerel until the killer comes, and then they know it, I tell you. Then the Horse-Mackerel will run! Some fishermen say that they have seen a killer poke his head out of the water with a Horse-Mackerel in his mouth. I have known a Horse-Mackerel to yield twenty-three gallons of oil. The average size is about eight feet in length."[1]

101. THE LITTLE TUNNY OR ALBICORE.

This fish, *Orcynus alliteratus*, known in the Gulf of Mexico, where it is confounded by the fishermen with other similar species, as the "Bonito," and in the Mediterranean by the names "Tonnina" (Trieste), "Carcàne" (Venice), and "Tanna" (Nice), has a geographical range very similar to that of the Bonito, except that it is found in the Pacific on the east coast of Japan, and in the Malay Archipelago. *It has also been recorded from Cuba, Brazil, and the Bermudas.* This active species, which attains the weight of from thirty to forty pounds, first made its appearance in our waters in 1871, when several large schools were observed by the Fish Commission in Buzzard's Bay and the Vineyard Sound. Nearly every year since, they have been seen in greater or less numbers, but, as they are of little value for food, no effort has been made to capture them, nor are they often brought to the markets. This species, known at the Bermudas as the "Mackerel," is frequently seen in the markets at Hamilton and Saint Georges.

In the Mediterranean its flesh is considered to be very excellent. My own experiments with it are hardly confirmatory of this statement, but in Southern Europe all the fishes of this family are very highly esteemed, and that it is not appreciated with us is perhaps due to the fact that we do not know how to cook them. I find the following note by Professor Baird: "Flesh, when cooked, dark brown all around the backbone, elsewhere quite dark, precisely like horse-mackerel. Flesh very firm, compact, and sweet."

Stearns records its frequent occurrence in the Gulf of Mexico, where he has observed individual specimens at Pensacola and Key West.

The habits of this fish have not been specially studied, but there is no reason to doubt that they correspond closely with those of others of the same family.

THE CARANGOID FISHES.

The members of the family *Carangidæ*, which is closely allied to the mackerel family, are distinguished chiefly by the form of the mouth, and by the fact that they have uniformly but twenty-four vertebræ, ten abdominal and fourteen caudal, while the mackerel have uniformly more, both abdominal and caudal. They are carnivorous fishes, abounding everywhere in temperate and tropical seas. On our own eastern coast there are at least twenty-five species, all of them eatable, but none of them of much importance except the Pompanoes. On the California coast there are two or three species of this family, of small commercial importance.

102. THE SILVER MOON-FISHES.

THE BLUNT-NOSED SHINER—SELENE SETIPINNIS.

This fish, known on some parts of the coast as the "Horse-fish," in North Carolina as the "Moonfish" or "Sunfish," and in Cuba by the name "Jorobado," was called by DeKay "Blunt-nosed Shiner," and since this name, sometimes varied to "Pug-nosed Shiner," is in common use in the New York market and in Narragansett Bay, while the other names are shared by other species,

[1] HORSE-MACKEREL.—One weighing three hundred pounds was harpooned at Minot's Ledge August 10, 1859, by a seaman on the United States steamer "Granite." Another, nine feet in length and weighing six hundred and fourteen pounds, in Marblehead Bay about the same time.

similar and dissimilar, it seems the most suitable for general adoption. The fish is found everywhere throughout the West Indies, as well as in Northern Brazil and in the Gulf of Guinea, the Gulf of Mexico, the Gulf of California, and southward along the coast to Panama, but has not been found in Europe. In Eastern Florida it is not very unusual, being frequently taken in the Lower Saint John's, and sometimes driven up as far as Jacksonville by easterly storms. Here and in the Indian River it is known as the "Moonfish." It is a frequent summer visitor all along the coast as far north as Wood's Holl, Massachusetts, where it has a peculiar name, the people there calling it the "Hump-backed Butterfish." The species attains the length of ten or twelve inches, and is esteemed an excellent article of food. Considerable numbers are brought yearly to New York, but elsewhere it rarely appears in the markets. Young from three inches in length upwards are found, but we have no definite knowledge as to its breeding habits.

THE SILVER MOON-FISH—SELENE ARGENTEA.

This species is almost certain to be confused by fishermen with the one last described, which it resembles and is often spoken of under the same names. It occurs abundantly on our coast as far north as Wood's Holl, and is found in the West Indies, in Brazil, and in the Gulf of Mexico, as well as in the Pacific, from the Gulf of California to Panama.

The young of the Silver Moon-fish is abundant in our waters, and has been frequently taken in Massachusetts Bay, and, in one or two instances, as far north as Halifax, Nova Scotia. Their bodies are so thin that they can be dried in the sun without the use of any preservatives, without loss of form and color. They are, consequently, of no importance for food. In the Chesapeake this fish is often called by the names "Horse-head" and "Look-down."

108. THE CAVALLY, THE SCAD, AND THE JURELS.

THE CAVALLY—CARANX HIPPOS.

The Cavally of the Gulf of Mexico and Eastern Florida—the "Horse Crevallé" of South Carolina—occurs abundantly on our Southern coast, and has been recorded by Professor Poey from Cuba and by Cope from St. Christopher and St. Croix. It is generally distributed throughout the West Indies, and is found along the Pacific coast from the Gulf of California to Panama. The species was originally described from specimens sent from South Carolina by Garden to Linnæus. The name of this fish is usually written and printed "Crevallé," but the form in common use among the fishermen of the South, "Cavally," is nearer to the Spanish and Portuguese names, *Cavalha* and *Caballa*, meaning "horse." The name as used in South Carolina is a curious reduplication, being a combination of the English and Spanish names for "horse." It should be carefully remembered that in South Carolina the name Crevallé is most generally applied to quite another fish, the Pompano.

The Cavally, as it seems most appropriate to call *Caranx hippos*, though in individual cases occurring as far north as Cape Cod, and even, in one instance, at Lynn, Massachusetts, is not commonly known in the United States north of Florida. Storer remarks: "This fish is so seldom seen in the waters of South Carolina that we are unacquainted with its habits." I observed a specimen in the Jacksonville market in April, 1874. Concerning the Cavally of Southern Florida, which is either this or a closely allied species, Mr. H. S. Williams writes:

"In the Indian River this is one of the best of the larger varieties. Its season is from the 1st of May to November. It ranges in weight from three to twenty pounds, being larger and more numerous to the southward toward the Mosquito Inlet. The south end of Merritt's Island and the inlets opposite old Fort Capron seem to be a sort of headquarters for the Cavalli. When in

pursuit of prey they are very ravenous and move with the rapidity of lightning. They readily take a troll either with bait or rag. The favorite mode of capturing them, as well as all other large fish that feed in shallow water or near the shore, is with a rifle. The high, rocky shores afford an excellent opportunity for this sport, though the rapid movements of the fish render them very difficult targets."

Mr. Stearns writes: "The Crevallé is common on the Gulf coast. In West Florida it appears in May and remains until late in the fall, and is equally abundant in the bays and at sea. In the bays it is noticeable from the manner in which it preys upon fish smaller than itself, the Gulf menhaden and mullet being the most common victims. On arrival it contains spawn which it probably deposits in the salt-water bayous, for in the fall schools of young are seen coming out of those places on their way to the sea. These young are then of about one pound weight, appearing to the casual observer like pompano, and I am told that they equal it for edible purposes. They are caught accidentally by seines and trolling-lines. Large ones are not considered choice food, the flesh being dark and almost tasteless. The average weight is twelve pounds; occasionally they attain the size of twenty pounds."

Professor Jordan found this species abundant in Lake Ponchartrain.

The Goggler—Caranx crumenophthalmus.

This fish, called in the Bermudas, where it is of some importance as a food-fish, the "Goggler," or "Goggle-eyed Jack," and in Cuba the "Cicharra," occurs in the West Indies and along the Atlantic coast of the United States north to the Vineyard Sound. It is also found at Panama and in the Gulf of California, and in the Indian Ocean, the Red Sea, and off the coast of Guinea, while, as has been remarked, it is abundant in the Bermudas. Its large, protruding eyes are very noticeable features, and the Bermuda name seems appropriate for adoption, since the fish has with us never received a distinctive name. In form it somewhat resembles the species last discussed, with which it is probably often confused.

Stearns speaks of a fish, common at Key West, which is known as the "Horse-eyed Jack," and this may prove to be the same species.

The Jurel—Caranx pisquetus.

This fish, known about Pensacola as the "Jurel," "Cojinua," and "Hard-tail"; along the Florida coast as "Jack-fish" and "Skipjack"; in the Bermudas as the "Jack" or "Buffalo Jack"; in South Carolina as the "Horse Crevallé"; at Fort Macon as the "Horse-Mackerel"; about New York and on the coast of New Jersey as the "Yellow Mackerel," is found in the Western Atlantic from Brazil, Cuba, and Hayti to Halifax, Nova Scotia, where specimens were secured by the United States Fish Commission in 1877. It is one of the commonest summer visitants of the West Indian fauna along the whole coast of Southern New England and the Middle States, being especially abundant in the Gulf of Mexico, and one of the commonest fishes in the Bermudas. This fish is occasionally brought to the New York market, but is of no special importance as an article of food north of the Gulf of Mexico. Concerning its habits in those waters, Mr. Stearns has contributed a very interesting series of notes. They are especially entertaining, since nothing has previously been known of its life-history:

"It is extremely abundant everywhere on the Gulf coast of Florida, Alabama, and Mississippi. At Pensacola it is one of the important fishes of trade, and is highly prized for food. It is one of the class of migratory fishes of this coast, like the pompano, mullet, Spanish mackerel, and red-fish, having certain seasons for appearing and disappearing on the coast, and also has habits during these seasons that are peculiar to themselves or their class. It appears on the coast in April, in

small schools that swim in shoal water near the beach during pleasant weather, when there is little or no surf, in eight or ten feet of water, and in stormy weather some little distance from the breakers. Their movement is from the eastward to the westward. As they seldom swim at the surface, their movements can be watched only when in shoal water. The schools 'running' in April and first of May are usually smaller than those of a few weeks later, but the individuals of the first are somewhat larger. The mass, or largest 'run,' comes in May, and it is on the arrival of these that schools are first seen coming in the inlets.

"A noticeable peculiarity of the Hard-tail compared with some other common migratory fishes is that the first schools do not stay about the mouths of an inlet and along the beach weeks before coming inside as those of the latter do, but continue their westward movement, without seeming to stop to feed or play, until the time has come for a general movement towards the bays. In this way they must be distributed along the coast, with no unequal accumulation at any one point. When once inside, the numerous schools break up into smaller ones of a dozen or two fish, which are found in all parts of the bay during the summer. On their arrival the larger fish contain spawn, which in July and August becomes quite full, after which none are seen but the young fish of about ten inches in length, until there is a general movement towards the sea. It is believed that the adult fish spawn in the bays, but the only evidence to support that belief is that they come inside with spawn, go away without it, and that very young fish are found there. In October and November small Hard-tails are caught in Santa Rosa Sound, measuring five and six inches in length.

"The smallest of the spring run are nine or ten inches long. Adult fish measure twelve, fourteen, and fifteen inches in length, very rarely more than the last. During the months of October and November Hard-tails leave the bays, formed in small schools and swimming below the surface in deep water. The only time that they can then be seen is when they cross the 'bars' at the inlet or sandy shoals in the bay. A few stragglers remain in Pensacola Bay and Santa Rosa Sound all winter, which are taken now and then with hook and line. I have found them in abundance in winter on the South Florida coast, where, owing to less variable conditions of the water, their habits are decidedly different. The Hard-tail is a most voracious fish, waging active war upon the schools of small fish. Its movements are rapid, and sometimes in its eagerness it will jump high out of the water. It has its enemies also, for I have seen whole schools driven ashore by sharks and porpoises; a great many are destroyed in this way. Hard-tails are caught for the market in seines."

The Cuba Jurel—Caranx fallax.

The occurrence of this species on our coast was first announced by a drawing made by Mr. J. H. Richard of a fish taken in South Carolina. Upon this drawing Holbrook founded his species, *C. Richardii*. *Caranx fallax* occurs abundantly throughout the West Indies and along the Gulf coast of the United States, and it is by no means impossible that stragglers should have found their way to Charleston. According to Professor Poey, this fish has been prohibited from sale in Cuba from time immemorial, and with good reason, since many disastrous cases of sickness have followed its use as food. This species occurs, according to Jordan, from the Gulf of California to Panama, and also in the East Indies.

The Round Robin—Decapterus punctatus.

The Round Robin, or, as it is called at Pensacola, the "Cigar-fish," occurs in the Bermudas, where it is an important food-fish; it occurs also in the West Indies and along the coast of the United States north as far as Wood's Holl.

A closely related species, *Decapterus macarellus*, is found also in the West Indies and along the eastern coast of the United States. According to Stearns, individuals of this species are rather rare in the northern part of the Gulf, but more common along the South Florida coast. They live in shallow water and in harbors, usually moving about in small schools. At Key West they are caught in seines, and are eaten.

The Scads—Trachurus saurus, etc.

The Scads, known in England as the "Horse-Mackerels," appear to occur in all temperate and tropical waters. The distribution is given by Günther as follows: "From the coasts of the temperate parts of Europe, along the coasts of Africa, round the Cape of Good Hope into the East Indian seas, to the coasts of New Zealand and West America." As has been shown by Lütken, Steindachner, and Jordan and Gilbert, three distinct species are confounded by Günther under the name *Trachurus trachurus*.

In Europe our Scad ranges north to the Trondhjem Fjord, latitude 65°, and is said to occur as far south as Portugal. On the coast of Holland it is known as the "Marse Banker," or "Hors." It is interesting to American ichthyologists, since the similarity of its habits to those of the menhaden, so important in our waters, caused the latter fish to be called among the early Dutch colonists of New York by the same name. European writers describe the Scads as occurring upon those coasts in schools of immense numbers, and it would seem that although their manner of swimming resembles that of the menhaden, in their other habits they more closely resemble our own bluefish. They are considered to be food-fishes of fair quality, and attain the length of about twelve inches. They are supposed to spawn about the same time as the mackerel. Only three specimens of this species have ever been taken in the United States, one by the Fish Commission in Southern New England in 1878, and subsequently two others by Jordan and Stearns, at Pensacola. In California, according to Jordan, the allied species *T. picturatus* occurs and is known as the "Horse-Mackerel." He continues: "It reaches a length of about a foot and a weight of less than a pound. It ranges from Monterey southward to Chili, appearing in California in the summer, remaining in the spawning season, and disappearing before December. It arrives at Santa Barbara in July, and at Monterey in August. In late summer it is exceedingly abundant. It forms part of the food of larger fishes, and great numbers are salted for bait. As a food-fish it is held in low esteem, but whether this is due entirely to its small size we do not know. It is identical with the well-known Mediterranean species."

The Thread-fish—Blepharis crinitus.

This fish, also known as the "Shoemaker-fish," is found along our coast from Cape Cod to the Caribbean Sea, as also on the Pacific coast of tropical America. It possesses no importance in our Atlantic waters, but on account of its strange shape and the long thread-like appendages to its fins, which float behind it to the distance of five or six times its own length, it is often brought *to the markets as a curiosity. "It is not found in California," writes Jordan, "but in* Western Mexico it attains the length of two or three feet, and is brought to the markets for food."

104. THE POMPANOS—TRACHYNOTUS CAROLINUS, ETC.

There are four species of Pompano in the Western Atlantic, very similar to each other in general appearance, but easily distinguished by differences in proportion and in the number of fin-rays.

The commonest and by far the most important species, the Carolina Pompano, *Trachynotus carolinus*, has the height of the body contained two to two and two-thirds times in the total length; the length of the head five to five and one-third times; one of the caudal lobes four times. It has

twenty-four to twenty-five rays in the second dorsal, while the anterior rays of the dorsal and anal fins, if laid backward, reach to the middle of the fin.

The Round Pompano (*T. ovatus*) has the height of the body contained two to two and one-third times in the total length; the length of the head five to five and one-fourth times; one of the caudal lobes three and a half to four times. In the second dorsal are from eighteen to twenty-one rays, in the second anal from sixteen to nineteen, while in the Carolina Pompano there are twenty-one to twenty-two.

The African Pompano (*T. goreensis*) resembles in general form the Round Pompano, though somewhat more elongate, while the head is larger, being contained four and a half times in the total length. The anterior rays of the dorsal and anal extend beyond the middle of the fin, if laid backward. In the number of the fin-rays it corresponds most closely with the Round Pompano.

The Banner Pompano (*T. glaucus*) has a somewhat elongate body and a small head. It is much thinner than either of the other species. Its silvery sides are marked with four blackish vertical streaks; the best distinguishing mark is in the length of the first rays of the dorsal and anal, which extend back nearly to the tip of the caudal fin. The name Pompano, applied in this country to all of these fishes, is a Spanish word, one of the meanings of which is "grape-leaf." This name is applied in Western Europe to a very different fish.

The Common Pompano—Trachynotus carolinus.

The Common Pompano or Carolina Pompano occurs in both the Atlantic and Pacific waters of the United States. On our eastern coast it ranges north to Cape Cod, south to Jamaica, east to the Bermudas, and west in the Gulf of Mexico, at least as far as the mouth of the Mississippi River. In the Pacific it is rare, and as yet known only from the Gulf of California, where it has recently been observed by Mr. C. H. Gilbert.

In our New England and Middle States it is a summer visitor, appearing in June and July, and departing in September. Although it is at present impossible to ascertain the lower limit of its temperature range, it is probable that it corresponds very nearly to that indicated by a harbor temperature of 60° to 65° Fahrenheit.

This species was described at an early day by Linnæus from South Carolina, and never had been observed in any numbers north of Cape Hatteras until the summer of 1854, when Professor Baird discovered them near Great Egg Harbor. In his "Report on the Fishes of New Jersey" he states that he had seen them taken by thousands in the sandy coves on the outer beach of Beasley's Point. These, however, were young fish, few of them weighing more than half a pound. In 1863 he obtained both species in Southern Massachusetts, where in subsequent years they have been frequently captured.

"My first acquaintance with the Pompano in New England," writes Professor Baird, "was in 1863, during a residence at Wood's Holl, where I not unfrequently caught young ones of a few inches in length. I was more fortunate in the summer of 1871, which I also spent at Wood's Holl; then the Pompano was taken occasionally, especially in Captain Spindle's pound, and I received at different times as many as twenty or thirty, weighing about one and one-half or two pounds each. Quite a number were caught in Buzzard's Bay and Vineyard Sound in 1872."

It is a fair question whether the Pompano has recently found its way into northern waters, or whether its presence was unknown because nobody had found the way to capture it. When Mitchill wrote on the fishes of New York in 1842 he had access to a single specimen which had been taken off Sandy Hook about the year 1820.

The spawning times and breeding grounds of these fishes are not well known. Mr. S. C.

Clarke states that in the Indian River they spawn in March, in the open sea near New Smyrna, Florida. It is supposed that those visiting our northern coasts breed at a distance from the shore. The eggs, like those of the mackerel, being lighter than the water, float at or near the surface. The Pompanoes may, however, be truly migratory, seeking the waters near the equator in winter and following along a coastwise migration, north and south, in summer. They are rapid, powerful swimmers; their food consists of mollusks, the softer kinds of crustaceans, and probably the young of other fishes. S. C. Clarke remarks that they have been known to bite at a clam bait. Genio Scott remarks: "It is mullet-mouthed; never takes a bait except by mistake." Their teeth are very small and disappear with age. As seen in the New York market they rarely exceed five or six pounds in weight. I quote in full the observations of Mr. Stearns:

"The common Pompano is abundant on the Gulf coast from the Mississippi River to Key West, and, as far as I can learn, is rare beyond this western limit until the Yucatan coast is reached, where it is common. It is considered the choicest fish of the Gulf of Mexico, and has great commercial demand, which is fully supplied but a few weeks in the year, namely, when it arrives in spring. The Pompano is a migratory fish in the Pensacola region, but I think its habits on the South Florida coast are such that it cannot properly be so classed.

"At Pensacola it comes in to the coast in spring and goes away from it in fall, while in South Florida it is found throughout the year. In the former section it appears on the coast in March in schools varying in numbers of individuals from fifty to three or four thousand, which continue to 'run' until the latter part of May, when it is supposed that they are all inside. Their movement is from the eastward, and they swim as near to the shore as the state of the water will permit, very seldom at the surface so as to ripple or break the water, although sometimes while playing in shoal water they will jump into the air.

"Before any schools enter the bays certain ones will remain for days, or even weeks, in a neighborhood, coming to the beach during the flood-tide to feed on the shell-fish that abound there and returning again to deeper water on the ebb-tide. The holes or gullies in the sand along the beach are their favorite feeding-grounds on these occasions. Sharks and porpoises pursue the Pompano incessantly, doubtless destroying many. The largest numbers come in April, and sometimes during that month the first schools are seen entering the inlets, others following almost every day, until about June 1, when the spring run is said to be over. Every year they appear in this way at Pensacola and adjoining bays, although there are many more some years than others. As the abundance is judged by the quantity caught I think that the difference may lie more in the number of fishing days (pleasant ones) than in the real numbers of fish present. The sizes of Pompano that make up these schools are large or adult fish averaging twelve or fourteen inches in length, and small fish (probably one year old) averaging eight inches in length. The largest Pompano that I have seen measured nineteen and a half inches in length, and weighed six and a quarter pounds, the extremely large fish called Pompano of two or three times that size probably being another species. After entering the bays the schools of Pompano break up and the fish scatter to all parts where the water is salt and there are good feeding grounds. Except single individuals that are taken now and then, nothing is seen of Pompano until late in the fall, when they are bound seaward. In regard to its spawning habits nothing very definite has been learned. It has spawn half developed when it arrives and has none when it leaves the bays. Large quantities of the fry are seen in the bays all summer, which is some proof of its spawning inside. In June, 1878, I caught specimens of the fry varying in size from three-quarters of an inch to three inches in length. Very many schools of these sizes were also observed in July and August of the same and following years of 1879–'80.

"The schools of fry go to sea in August and September. The older or adult fish leave the coast in September and October in small schools, that are only seen and caught at the inlets where they happen to cross shoals or follow the beach. These Pompano of the fall are very fat and in every way superior to those caught in the spring. As before mentioned, the Pompano is found on the South Florida coast all the year. The sea-beach from Tampa Bay to Charlotte's Harbor seems to be its favorite feeding-ground owing to the quantity of shell-fish that occur there. It does not form in large schools as in the Pensacola region, and therefore is not taken in such large quantities by seine fishermen.

"Smacks from Mobile and Pensacola sometimes go to Tampa Bay for them. I have been told that Pompano are caught at Key West in considerable quantities by hook and line, and I have known of a few being taken in that manner at Pensacola. It feeds entirely upon small shell-fish, which are crushed between the bones of its pharyngeal arch."

The Round Pompano—Trachynotus ovatus.

The Round Pompano, in the South sometimes called the "Shore Pompano," is known in the Bermudas by the name "Alewife." This fish is very often confused by market-men with the Carolina Pompano, and I have seen them sold together in the Charleston market under the same name, just as I have seen the young of four species of the herring family sold indiscriminately in New York.

The Round Pompano is cosmopolitan in its distribution, occurring in the North and South Atlantic, and in various parts of the Indian Ocean. The young have been obtained in the harbor of Vineyard Haven, Massachusetts, and at Beaufort, South Carolina. It is probable that the species is far more abundant in our waters than we now suppose it to be. About the Bermudas they are sometimes very abundant, and in 1875 a school of them, numbering six or seven hundred, was seined on the south shore of the islands. They are there highly esteemed for table use.

The African Pompano—Trachynotus goreensis.

This species, originally described from the Island of Gorea, on the west coast of Africa, was observed by the writer at the Bermudas in 1876, and in 1877 was discovered in Florida. It is the largest of the Pompanos. Two or three specimens, weighing from fifteen to twenty pounds each, have been sent from Florida to the New York market. One of these, taken at Jupiter Inlet, was sent by Mr. Blackford to the National Museum. In the Gulf of Mexico it is not unusual, being known at Key West as the "Permit."

Stearns remarks: "This fish is rather common along the lower end of the Florida Peninsula, specimens being caught quite often in seines at Cedar Keys, and at the mullet fisheries of Sarasota and Charlotte's Harbor, and also Key West. It is said to attain a considerable size—fifteen or twenty pound specimens being common. It is not a choice food-fish when so large, and even smaller ones are comparatively dry and tasteless. I have not found it north or west of Cedar Keys."

The Banner Pompano—Trachynotus glaucus.

This species is a member of the West Indian fauna, and occasionally occurs at the Bermudas. Stearns remarks that it is obtained frequently at Pensacola with the other species, but is never very common, is seen only in the spring, and is not valued as a food-fish. Professor Jordan writes: "Along the Carolina and Gulf coasts it is not rare. At Pensacola it is known as the 'Gaff-topsail Pompano,' and is held in low esteem." An allied species, *Trachynotus fasciatus*, has lately been noticed by Jordan and Gilbert on the Pacific side of the Isthmus of Panama.

105. THE PILOT-FISH—NAUCRATES DUCTOR.

The Pilot-fish, though of little or no economic importance, deserves passing mention, since it is so frequently referred to in literature. It is occasionally taken on our coast. Captain Atwood mentions a specimen which was taken in a mackerel net in Provincetown Harbor, in October, 1858. A whale-ship had come in a few days before, and he supposes that the Pilot-fish had followed it into the harbor.

"The Pilot-fish (*N. ductor*) is a truly pelagic fish, known in all tropical and temperate seas. Its name is derived from its habit of keeping company with ships and large fish, especially sharks. It is the Pompilus of the ancients, who describe it as pointing out the way to dubious or embarrassed sailors, and as announcing the vicinity of land by its sudden disappearance. It was therefore regarded as a sacred fish. The connection between the shark and the Pilot-fish has received various interpretations, some observers having, perhaps, added more sentiment than is warranted by the actual facts. It was stated that the shark never seized the Pilot-fish; that the latter was of great use to its big companion in conducting it and showing it the way to its food. Dr. Meyer, in his 'Reise um die Erde,' states: 'The Pilot swims constantly in front of the shark; we ourselves have seen three instances in which the shark was led by the Pilot. When the shark neared the ship the Pilot swam close to the snout, or near one of the pectoral fins of the animal. Sometimes he darted rapidly forwards or sidewards, as if looking for something, and constantly went back again to the shark. When we threw overboard a piece of bacon fastened on a great hook, the shark was about twenty paces from the ship. With the quickness of lightning the Pilot came up, smelt at the dainty, and instantly swam back again to the shark, swimming many times round his snout and splashing as if to give him exact information as to the bacon. The shark now began to put himself in motion, the Pilot showing him the way, and in a moment he was fast upon the hook.[1] Upon a later occasion we observed two Pilots in sedulous attendance on a blue shark which we caught in the Chinese Sea. It seems probable that the Pilot feeds on the shark's excrements, keeps his company for that purpose, and directs his operations solely from this selfish view.' We believe that Dr. Meyer's opinion, as expressed in his last words, is perfectly correct. The Pilot obtains a great part of his food directly from the shark, in feeding on the parasitic crustaceans with which sharks and other large fish are infested, and on the smaller pieces of flesh which are left unnoticed by the shark when it tears its prey. The Pilot, also, being a small fish, obtains greater security when in company of a shark, which would keep at a distance all other fishes of prey that would be likely to prove dangerous to the Pilot. Therefore, in accompanying the shark, the Pilot is led by the same instinct which makes it follow a ship.

"With regard to the statement that the Pilot itself is never attacked by the shark, all observers agree as to its truth; but this may be accounted for in the same way as the impunity of the swallow from the hawk, the Pilot-fish being too nimble for the unwieldy shark.

"The Pilot-fish does not always leave the vessels on their approach to land. In summer, when the temperature of the sea-water is several degrees above the average, Pilots will follow ships to the south coast of England into the harbor, where they are generally speedily caught. Pilot-fish attain a length of twelve inches only. When very young their appearance differs so much from the mature fish that they have been described as a distinct genus, *Nauclerus*. This fry is exceedingly common in the open ocean, and constantly obtained in the tow-net; therefore the Pilot-fish retains its pelagic habits also during the spawning season, and some of the spawn found by voyagers floating on the surface is, without doubt, derived from this species."[2]

[1] In this instance one may entertain reasonable doubts as to the usefulness of the Pilot to the shark.

[2] GÜNTHER: Study of Fishes, p. 414.

The Pilot-fish has been observed in one or two instances about New York, and has also been recorded from South Carolina. It is, however, rare in the Western Atlantic, and our museums have very few specimens.

106. THE AMBER-FISHES AND THE LEATHER-JACKETS.

The Amber-fish—Seriola carolinensis.

Mr. Silas Stearns writes concerning the habits of this fish in the Gulf of Mexico:

"The Amber-fish is quite common off the West Florida coast, occurring in from ten to thirty fathoms of water on or near the 'snapper banks' throughout the year. It is a very active fish, swimming just below the water's surface, preying upon schools of small fish. It is rather shy of a baited hook, and but few are caught. It is a good food-fish. It attains a size of forty inches length and fifteen pounds weight. Its average size but little more than half that." It is also, according to Jordan, rather common on the Carolina coast, where it is known as the "Jack-fish."

The Pensacola Rock Salmon—Seriola falcata.

The "Rock Salmon" of Pensacola, *Seriola falcata*, is recorded by Stearns as occasionally occurring near Pensacola in company with the preceding species, which it resembles in habits. It is caught with hook and line and is eaten; in his opinion, it attains a larger size than the Amber-fish. There is a third species of Amber-fish of which the National Museum has received a single specimen from South Florida. It is closely related to the fish described by Cuvier under the name *Seriola Lalandii*. The same species is sometimes sent to the New Orleans market, where an example was seen by Professor Jordan.

The California Yellow-tail—Seriola dorsalis.

Another closely allied species, *Seriola dorsalis*, occurs on the coast of California, where, according to Jordan, it is known under the names "Yellow-tail," "White Salmon," and "Cavasina."

Of the "Yellow-tail," Professor Jordan says: "It reaches a length of four to five feet, and a weight of thirty to forty pounds, and individuals of less than fifteen pounds weight are rarely seen. It ranges from Cape San Lucas northward to the Santa Barbara and Coronados Islands, where it is found in great abundance in the spawning season, arriving in July, and departing in early fall. It spawns about August 18. It is caught chiefly by trolling. It feeds on squid and such fish as the anchovy and sardine. As a fresh fish it ranks high, although large individuals are sometimes coarse and tough. When salted and dried it is inferior to none on the coast, ranking with the white-fish and barracuda."

The Banded Rudder-fish—Seriola zonata.

This species has been observed as far north as Salem and Beverly, Massachusetts. Several specimens have been taken north of Cape Cod during the past forty years. It is a small fish, rarely exceeding six or eight inches in length, conspicuous by reason of its brilliant and beautiful colors, and good to eat, though rarely saved by the fishermen who accidentally capture it. It is called in Southern New England the "Rudder-fish" on account of its resemblance to the Rudder-fish of the ocean, *Naucrates ductor*.

The Medregal—Seriola fasciata.

This fish, called in Cuba the "Medregal" and in Bermuda the "Bonito", has been observed in South Florida and along the coasts of the Carolinas. It is apparently exceedingly rare in the

waters of the United States. In Bermuda it attains a length of two feet or more, and is highly esteemed as a food-fish.

THE LEATHER-JACKET—OLIGOPLITES SAURUS.

This fish, which is found throughout the West Indies and south as far as Bahia, and on the Pacific coast of Mexico and Central America, has since 1875 been several times observed between Florida and Newport, Rhode Island. It is known to fishermen as the "Skipjack," sharing this name with a number of other scombroid fishes which leap from the water as they pursue their prey. It is one of the most beautiful and graceful fishes in our waters, but at present is of no economic importance, its flesh being hard and dry.

THE RUNNER—ELAGATIS PINNULATUS.

This West Indian fish, known at Key West as "Skipjack" or "Runner," and at Pensacola as "Yellow-tail" or "Shoemaker," is, according to Stearns, "abundant on the western and southern coasts of Florida. At Pensacola it spawns in spring; the young fish are seen in July and August. It is found in the bays and along the sea-beaches, seeming to prefer clear, salt water, swift currents, and sandy bottoms. It usually moves in small schools of a dozen or two individuals. It feeds upon small fishes and crustaceans. When pursued by larger fish it jumps repeatedly from the water, very much in the same manner as the flying fish, only its flights are much shorter and oftener repeated. This habit has given it the names of 'Skipjack' and 'Runner' at Key West, where it may be seen at almost any time. It is sometimes eaten at Key West, and at Havana is quite an important fish in the markets, being also exposed for sale at stands on the streets, cooked and ready for use."

107. THE DOLPHINS—CORYPHÆNIDÆ.

The Dolphins are found usually in mid-ocean, where they feed upon other pelagic fishes, such as the flying-fish. They are strong, rapid swimmers, and are widely distributed throughout all temperate and tropical waters. The name Dolphin is wrongly applied to them, being the peculiar property of a group of small cetaceans. They are often caught by sailors at sea, and are considered most excellent food. It is an almost universal custom before eating them to test the flesh by putting a piece of silver into the vessel in which they have been cooked, it being a common belief that if the flesh is poisonous the silver will turn dark. Narratives of ocean voyages abound in descriptions of the beautiful colors of the Dolphin and the brilliant changes of hue exhibited by the dying fish. There are in the Atlantic two species of Dolphins, though the number was, until lately, supposed to be very much greater. But one of these, *Coryphæna hippurus*, is definitely known from our shores.

The young, less than two feet in length, are beautifully marked with numerous small circular spots, and have, until lately, been considered by many writers to belong to a distinct genus and species. Dolphins are abundant also, it is said, in the Gulf of Mexico.

THE STROMATEOID FISHES.

108. THE RUDDER-FISH FAMILY—STROMATEIDÆ.

The family *Stromateidæ* is represented on the east coast by three species, two of which are important food-fishes, and in our Pacific waters by one species, the so-called "California Pompano." The family is a small one, and is widely distributed throughout the warm seas.

The Butter-fish—Stromateus triacanthus.

The "Butter-fish" of Massachusetts and New York, sometimes known in New Jersey as the "Harvest-fish," in Maine as the "Dollar-fish," about Cape Cod as the "Sheepshead" and "Skipjack," in Connecticut as the "Pumpkin-seed," and at Norfolk as the "Star-fish," is common between Cape Cod and Cape Henry. It has been observed south to South Carolina and north to Maine. It has been found in some abundance along the north side of Cape Cod in nets with bass and mackerel. It is a summer visitor, appearing in our waters in company with the mackerel and disappearing about the same time. It appears to breed in the sounds and in the open ocean in June and July, and the young are found in great abundance in July, August, and September, swimming about in company with certain species of jelly-fish. During these months several large species of jelly-fish, or sun-squalls, are found abundantly floating about in waters near the shore, and each one of these is almost invariably accompanied by ten or twelve, or more, young Butter-fishes, which seem to seek shelter under their disks, and which, perhaps, may obtain a supply of food from among the numerous soft-bodied invertebrates which are constantly becoming attached to the floating streamers of their protectors. The young fish, thus protected, range from two to two and a half inches in length. I have seen fifteen, and more, sheltered under an individual of *Cyanea arctica* not more than three inches in diameter. This refuge is not always safe for the little fishes, for they sometimes are destroyed by the tentacles of their protector, which are provided, as every one knows, with powerful lasso cells. The little fish seem to rise at the approach of danger and seek refuge among the lobes of the actinostome. They are, of course, thus safe from the attacks of many kinds of larger fishes which prey upon them, but they themselves often fall victims to the stinging power of the jelly-fish and are devoured. The habit of thus seeking shelter is very much like that of the rudder-fish. The Butter-fish attains an average size of seven or eight inches in length, and is very often taken in the pounds. The fishermen of Noank, Connecticut, tell me that often a barrelful of them is taken in one haul of a pound-net. They are much valued for food at New Bedford. When sent to New York they command a good price, and the poundmen at Lobsterville sometimes eat them and consider them better than scup. Their flavor is excellent, resembling that of the mackerel, though less oily; it is very palatable when nicely broiled. At many places, for instance, Noank and Wood's Holl, they are thrown away. Storer stated that they were extensively used as manure in certain parts of Massachusetts. No observations have been made upon their food, though, since their mouths are nearly toothless, it seems probable that they subsist, for the most part, upon minute vertebrates. These fishes are remarkable on account of their brilliant, iridescent colors, which, in freshly caught individuals, are as beautiful as those of a dolphin.

The Harvest-fish—Stromateus alepidotus.

This species has not been observed north of New York. Mitchill referred to it in his work on the fishes of New York, published in 1815, saying that it derived its common name, "Harvest-fish," from the fact that it usually appeared during harvest time. DeKay, too, mentions having had several specimens in his possession. It is somewhat abundant at the mouth of the Chesapeake and along the Southern coast. In the Gulf of Mexico it is rather rare; occasionally it is taken in seines at Pensacola. Dr. Günther, in his "Catalogue of the Fishes of the British Museum," makes the astounding statement that he has seen specimens from Lake Champlain. The species ranges south to Bahia, Brazil. It is not commercially valuable except at Norfolk, Virginia, where it is consumed for food in large quantities, its market name being "Whiting."

The California Pompano—Stromateus simillimus.

The California Pompano, *Stromateus simillimus*, is thus described by Professor Jordan:

"This species, known here as the Pompano, reaches a length of eight inches and a weight of rather less than half a pound. It occurs along the entire coast of California and Oregon, being most abundant about Santa Barbara and Soquel, and is not known from farther south than San Diego. It appears in schools chiefly in the summer and fall; occasionally, also, during the winter, its times of arrival and departure being quite variable. It is said that it was an extremely rare visitant till about 1870, and that its abundance since then has steadily increased, it being now often found in greater quantities than can be readily sold. It feeds on worms, small crustacea, &c. Nothing special is known of its breeding habits. As a food-fish it is held in the highest repute, the price of individual fish ranging from two to four for a 'quarter.' Its flesh is fat, rich, and excellent."

The Black Rudder-fish—Lirus perciformis.

This fish is also called by the fishermen "Log-fish" and "Barrel-fish." It has been observed at various points along our coast from New Jersey to Nova Scotia, where schools of them were several times observed off Halifax in 1877. It has hitherto been considered very rare north of Cape Cod. I cannot doubt that it will be hereafter found at least as far south as Cape Hatteras and probably along the whole length of our Atlantic coast. The habits of this fish are peculiar in the extreme. They are almost always found in the vicinity of floating barrels and spars, sometimes inside of the barrels; hence the fishermen often call them "Barrel-fish," though the most usual name is "Rudder-fish." They are occasionally taken in lobster-pots. When cruising in the Fish Commission yacht "Mollie," off Noman's Land, July 13, 1875, we observed numerous specimens swimming under floating spars and planks. Sometimes as many as from fifty to seventy-five were observed under a single spar, a cloud of shadowy black forms being plainly visible from the deck. We went out to them in a row-boat and succeeded in taking thirteen of them in the course of a day. After the first thrusts of the dip-net they grew shy and sought refuge under the boat, under which they would sink far below our reach. A lull of a few moments would bring them back to the log under which they had clustered until disturbed again. When the boat was rowed away they followed in a close-swimming school until we gained full speed, when they suddenly turned, as if by one impulse, and swam back to the log or spar. Once they followed us about two hundred yards from the spar, and then leaving us retreated to their old shelter, reaching it some time before we could turn the boat and row back to it. I had before this supposed them to be quite unusual, but on this one day we must have seen two hundred or two hundred and fifty at the lowest computation. They doubtless have gained the name of Rudder-fish from the sailors who have seen them swimming about the sterns of becalmed vessels.

When the Fish Commission steamer has been dredging off Halifax, I have several times noticed schools of them hovering around her sides. They doubtless gather around the logs for the purpose of feeding upon the hydroids and minute crustaceans and perhaps mollusca which accumulate around them. Their stomachs were found to contain amphipod crustaceans, hydroids, and young squids. They are doubtless to some degree protected by the spars under which they congregate, in the same manner as their kindred, the Butter-fish, which swim under the disk of the jelly-fish. Their colors undergo considerable change from time to time, possibly at the will of the fish.

The Rudder-fish attains the length of ten or twelve inches, and is excellent eating. DeKay states that the fishermen of New York, in 1842, called this species the "Snip-nosed Mullet," but this name does not appear to have become permanent.

109. THE DORY, HEN-FISH, AND OPAH FAMILIES.

The Dory Family—Zenidæ.

The fishes of this family are found in all temperate and tropical seas. The Boar-fish and the John Dory, both somewhat important species in Great Britain, are members of this and related families. A single specimen, recorded by Storer and Gill, the species which is peculiar to America and described under the name *Zenopsis ocellatus*, was taken off Provincetown.

The Hen-fish Family—Bramidæ.

The only member of this family of interest to us is the *Brama Raii*, called "Pomfret" in Bermuda, where a few individuals were observed by the writer in 1876. In 1880 an individual was obtained on the Grand Bank of Newfoundland, and more recently the species has been found to be somewhat abundant on the coast of Washington Territory and Vancouver's Island. This species was described from the coast of South America under the name *Brama chilensis*.

The Opah Family—Lamprididæ.

This family is represented in the Atlantic by a single species, *Lampris guttatus*, a pelagic fish, which appears to be more abundant in the deep waters of northern seas than elsewhere. It has been observed at many points upon the Norwegian coast, about Iceland and Madeira, as well as in the Mediterranean, but is of unusual occurrence everywhere, except perhaps about Madeira. On the coast of England it is one of the great rarities, and is much sought for by collectors on account of its beauty. It is said to be one of the most brilliantly colored fishes known—"red and green, with tints of purple and gold dotted over with silvery round spots. Iris of the eye is scarlet, and fins of lively red." A specimen was obtained years ago near Sable Island, Nova Scotia, and the species will doubtless be found still nearer our shores. It is said that no young specimens have yet been seen. The species attains the length of four feet and more, and is said to be very excellent for eating.

110. THE CUTLASS-FISH—TRICHIURUS LEPTURUS.

This fish is unfortunately known in Eastern Florida and at Pensacola as the "Sword-fish"; at New Orleans, in the Saint John's River, and at Brunswick, Georgia, it is known as the "Silver Eel," on the coast of Texas as "Sabre-fish," while in the Indian River region it is called the "Skipjack." No one of these names is particularly applicable, and the latter being preoccupied, it would seem advantageous to use in this country the name "Cutlass-fish," which is current for the same species in the British West Indies.

Its appearance is very remarkable on account of its long, compressed form and its glistening silvery color. The name "Scabbard-fish," which has been given to an allied species in Europe, would be very proper also for this species, for in shape and general appearance it looks very like the metallic scabbard of the sword. It attains the length of four or five feet, though ordinarily not exceeding twenty-five or thirty inches. This species is found in the tropical Atlantic, on the coast of Brazil, in the Gulf of California, the West Indies, the Gulf of Mexico, and north to Wood's Holl, Massachusetts, where, during the past ten years, specimens have occasionally been taken. In 1845 one was found at Wellfleet, Massachusetts; and in the Essex Institute is a specimen which is said to have been found in Salem Harbor. The species occurs also on the coast of Europe, two specimens having been found on the shores of the Moray Frith many years ago, and during the past decade it has become somewhat abundant in Southern England. It does not, however, enter the Mediterranean. Some writers believe the allied species, *Trichiurus haumela*, found in the Indian

Ocean and Archipelago and in various parts of the Pacific, to be specifically the same. The Cutlass-fish is abundant in the Saint John's River, Florida, in the Indian River region, and in the Gulf of Mexico. Several instances were related to me in which these fish had thrown themselves from the water into row-boats, a feat which might be very easily performed by a lithe, active species like the *Trichiurus*. A small one fell into a boat crossing the mouth of the Arlington River, *where the water is nearly fresh.*[1]

Many individuals of the same species are taken every year at the mouth of the Saint John's River, at Mayport. Stearns states that they are caught in the deep waters of the bays about Pensacola, swimming nearly at the surface, but chiefly with hooks and lines from the wharves. He has known them to strike at the oars of the boat and at the end of the ropes that trailed in the water. At Pensacola they reach a length of twenty to thirty inches, and are considered good food-fish. Richard Hill states that at Jamaica this species is much esteemed, and is fished for assiduously in a "hole," as it is called, that is, a deep portion of the waters off Fort Augusta. This is the best fishing place for the Cutlass-fish, *Trichiurus*. The fishing takes place before day; all *lines are pulled in as fast as they are thrown out, with the certainty that the Cutlass has been* hooked. As many as ninety boats have been counted on this fishing ground at day-break during the season. All carry on this kind of uninterrupted hauling in of fish.

A closely allied species, *Lepidopus caudatus*, is the "Scabbard-fish" of Europe, which also occurs in the Gulf of California. In New Zealand it is called the "Frost-fish," and is considered the most *delicious food-fish of the colony.*

111. THE SWORD-FISH FAMILY—XIPHIIDÆ.

Although it may not seem desirable at present to accept in full the views of Dr. Lütken regarding the specific unity of the Spear-fishes and the Sail-fishes of the Atlantic and Indian Oceans, it is convenient in discussing their geographical distribution to group the different species in the manner he has suggested.

The Sword-fish, *Xiphias gladius*, ranges along the Atlantic coast of America from *Jamiaca*, latitude 18° N., Cuba, and the Bermudas, to Cape Breton, latitude 47°. It has not been seen at Greenland, Iceland, or Spitzbergen, but occurs according to Collet, at the North Cape, latitude 71°. It is abundant along the coasts of Western Europe, entering the Baltic and the Mediterranean. I can find no record of the species on the west coast of Africa south of the Cape Verdes, though Lütken, who may have access to facts unknown to me, states that they occur clear down to the Cape of Good Hope, South Atlantic in mid-ocean, west coast of South America and north to Southern California, latitude 34°, New Zealand, and in the Indian Ocean off Mauritius. Good authorities state that sperm-whales, though constantly passing Cape Horn, never round the Cape of Good Hope. Can this be true in the case of the Sword-fish?

The Sail-fish, *Histiophorus gladius* (with *H. americanus* and *H. orientalis*, questionable species, and *H. pulchellus* and *H. immaculatus*, young), occurs in the Red Sea, Indian Ocean, Malay Archipelago, and south at least as far as the Cape of Good Hope, latitude 35° S.; in the Atlantic on the coast of Brazil, latitude 30° S. to the equator, and north to Southern New England, latitude 42° N.; in the Pacific to Southwestern Japan, latitude 30° to 10° N. In a general way the range may be said to be in tropical and temperate seas, between latitude 30° S. and 40. N., and in the western parts of those seas.

The Bill-fish or Spear-fish, *Tetrapturus indicus* (with various related forms, which may or may not be specifically identical, occurs in the Western Atlantic from the West Indies, latitude 10° to 20° N.,

[1] Exsiliens ex aquis sæpe in cymbam.—LINNÆUS.

to Southern New England, latitude 42° N.; in the Eastern Atlantic, from Gibraltar, latitude 45° N., to the Cape of Good Hope, latitude 30° S.; in the Indian Ocean, the Malay Archipelago, New Zealand, latitude 40° S., and on the west coast of Chili and Peru. In a general way, the range is between latitude 40° N. and latitude 40° S.

The species of *Tetrapturus* which we have been accustomed to call *T. albidus*, abundant about Cuba, is not very unusual on the coast of Southern New England. Several are taken every year by the Sword-fish fishermen. I have not known of their capture along the Southern Atlantic coast of the United States. All I have known about were taken between Sandy Hook and the eastern part of George's Banks.

The Mediterranean Spear-fish, *Tetrapturus belone*, appears to be a land-locked form, never passing west of the Straits of Gibraltar.

NAMES OF THE SWORD-FISH.—The names all have reference to its most prominent feature, the prolonged snout. The "Sword-fish" of our own tongue, the "*Zwaard-fis*" of the Hollander, the Italian "*Sifio*" and "*Pesce-spada*," the Spaniard's "*Espada*," "*Espadarte*," and varied by "*Pez de spada*" in Cuba, and the French "*Espadon*," "*Dard*," and *Épée de Mer*," are simply variations of one theme, repetitions of the "*Gladius*" of ancient Italy, and "*Xiphias*," the name by which Aristotle, the father of zoology, called the same fish twenty-three hundred years ago. The French "*Empereur*," and the "*Imperador*" and "Ocean King-fish" of the Spanish and French West Indies, carry out the same idea; the Roman emperor was always represented holding a drawn sword in his hand. The Portuguese names are "*Agulha*" and "*Agulhao*," meaning "needle" or "needle-fish."

This species has been particularly fortunate in escaping the numerous redescriptions to which almost all widely distributed forms have been subjected. By the writers of antiquity it was spoken of under its Aristotelian name, and in the tenth edition of his Systema Naturæ, at the very inception of binomial nomenclature, Linnæus called it *Xiphias gladius*. By this name it has been known ever since, and only one additional name is included in its synonymy, *Xiphias Rondeletii*, Leach.

The Sword-fish has been so long and so well known that its right to its peculiar name has seldom been infringed upon. The various species of *Tetrapturus* have sometimes shared its title, and this is not to be wondered at, since they closely resemble *Xiphias gladius*, and the appellative has frequently been applied to the family *Xiphiidæ*—the Sword-fish family—which includes them all.

The name "Bill-fish," usually applied to the *Tetrapturus albidus*, a fish of the Sword-fish family often taken on our coast, and described below, is objectionable, since it is in many districts used for the various species of *Belonidæ*, the "gar-fishes" or "green-bones" (*Belone truncata* and others), which are members of the same fauna. "Spear-fish" is a much better name.

The "Sail-fish," *Histiophorus americanus*, is called by sailors in the south the "Boohoo" or "Woohoo." This is evidently a corrupted form of "Guebucu," a name, apparently of Indian origin, given to the same fish in Brazil. It is possible that the *Tetrapturus* is also called "Boohoo," since the two genera are not sufficiently unlike to impress sailors with their differences. Bleeker states that in Sumaha the Malays call the related species *H. gladius* by the name "Jooboo" (*Juhu*), a curious coincidence. The names may have been carried from the Malay Archipelago to South America, or *vice versa*, by neighbors.

In Cuba the Spear-fishes are called "*Aguja*" and "*Aguja de Palada*"; the Sail-fish, "*Aguja, Prieta*" or "*Aguja Voladora*"; *Tetrapturus albidus* is specially known as the "*Aguja Blanca*," *T. albidus* as the "*Aguja de Casta*."

In the West Indies and Florida the scabbard-fish or silvery hair-tail, *Trichiurus lepturus*, a form allied to the *Xiphias*, though not resembling it closely in external appearance, is often called

"Sword-fish." The body of this fish is shaped like the blade of a saber, and its skin has a bright metallic luster like that of polished steel; hence the name.

The various species of sticklebacks, *Gasterosteus aculeatus* and *Pygosteus pungitius*, are known as "Little Sword-fish" by the boys of Portland, Maine, and vicinity. The spines, damaging in the extreme to small fingers of tyro fish-gatherers, give reason to the name.

Sail-fish appear to occur throughout the tropical and southern parts of the Atlantic and the Indian Ocean. Its names, wherever it may be found, point to the most striking characters. In Maregrave's time the Portuguese of Brazil called it "*Bicuda*," referring to its snout, and Rochefort, in his "History of the West Indies," calls it "*Bécasse de Mer*"; a *bécasse* being a long snouted bird like a woodcock or a snipe, while in the Malay Archipelago the Dutch call it "*Zee-snip*" or "Sea-snipe." The Malays of Amboyna called it the "*Ikan-layer*" or Fan-fish, in allusion to the fan-like movements of its dorsal fin, while those of Sumatra called it "*Ikan-jegan*" or "Sail-fish." The French "*Voilier*" and the Dutch "*Zeyl-fisch*" and "*Bezaan fisch*" mean the same; a *bezaan* being the sail upon the mizzen mast of a ship. The family name is "*Myl-meen*," signifying "Peacock-fish." The names "*Boohoo*" and "*Woohoo*" have already been referred to.

GEOGRAPHICAL DISTRIBUTION AND MOVEMENTS.—The Sword-fish was known to Pliny, who wrote: "The Sword-fish, called in Greeke Xiphias, that is to say in Latin Gladius, a sword, hath a beake or bill sharp pointed, wherewith he will drive through the sides and plankes of a ship, and bouge them so, that they shall sinke withall. The experience whereof is scene in the ocean, neare to a place in Mauritania called Gotta, which is not far from the river Lixos."[1]

Many other classical and mediæval writers made curious allusions to the Sword-fish. The summary of their views is given by Bloch, and is quoted below. This summary is very satisfactory though the skepticism of this author is sometimes a little excessive:

"This fish is found in the North Sea and the Baltic, but is rare in those waters. In the Mediterranean, however, it is very abundant. It lives for the most part in the Atlantic, where in winter it is found in mid-ocean. In spring it appears on the coast of Sicily, where its eggs are deposited on the bottom in great numbers. However, according to what I have been told by the illustrious Chevalier Hamilton, it is never seen in that region more than three or four feet long. The larger ones, often weighing four or five hundred pounds, and eighteen to twenty feet long, are found on the coast of Calabria, where they appear in June and July. Pliny remarked that they often exceed the dolphin in size. . . .

"Various writers have spoken of the 'Emperor of the Sea' as occurring in the Baltic. Olearius and Schelhammer record its capture near Holstein; Schoneveld mentions one from Mecklenburg; Walbaum one from the vicinity of Lübeck; Hanover and Klein one from the vicinity of Danzig; Hartmann one from near Pillau, and Wolf another taken near Königsberg.

"One mentioned by Schoneveld as taken near Mecklenburg was so large that it required two strong horses to draw it from the water. The body, without the sword, was eleven feet long, the sword three. The eyes were as large as hens' eggs, and the tail was two feet broad. Of four seen by Professor Koelpin during his stay at Greifswald, one measured more than three and one-half feet in circumference. . . .

"These fish, according to the story of the Chevalier Hamilton, always appear in pairs as they approach Messina, a female and a male together.

"This fish lives upon marine plants and fish. It has such a terrible defensive weapon that other voracious fishes do not dare to attack it. According to Aristotle, it is, like the tunny, tormented by an insect, and in its fury leaps out of the sea and even into vessels. According to

[1] Holland's Pliny, ii, p. 428.

Statius Müller, the skin is phosphorescent at night. Although such large fishes are not usually well flavored, this one is considered palatable. Pieces of the belly and the tail are especially esteemed, and hence they are expensive. The fins are salted and sold under the name '*callo*'. . . .

"Ælian errs in saying that it enters fresh water, and in cataloguing it among the fishes of the Danube."

ALLUSIONS TO THE SWORD-FISH IN AMERICA BY EARLY WRITERS.—The ancient city of Siena, secluded and almost forgotten among the hills of Northern Italy, should have a peculiar interest for Americans. Here Christopher Columbus was educated, and here, in the height of his triumphs as a discoverer, he chose to deposit a memento of his first voyage across the seas. His votive offering hangs over the portal of the old collegiate church, closed for many years, and rarely visited save by enterprising American tourists. It consists of the helmet and armor worn by the discoverer when he first planted his feet on New World earth, his weapons, and the weapon of a warrior killed by his party when approaching the American coast—the sword of a Sword-fish.[1]

It is not probable that Columbus, or some of his crew, seafaring men of the Mediterranean, had never seen the Sword-fish. Still, its sword was treasured up by them, and has formed for more than four centuries and a half a striking feature in the best preserved monument of the discoverer of America.

The earliest allusion in literature to the existence of the Sword-fish in the Western Atlantic seems to occur in Josselyn's "Account of Two Voyages to New England," printed in 1674, in the following passage:

First Voyage:—"The Twentieth day, we saw a great number of Sea-bats, or Owles, called also flying fish, they are about the bigness of a Whiting, with four tinsel wings, with which they fly as long as they are wet, when pursued by other fishes. Here likewise we saw many Grand pisces, or Herring-hogs, hunting the scholes of Herrings, in the afternoon we saw a great fish called the Vehuella or Sword-fish, having a long, strong and sharp finn like a Sword-blade on the top of his head, with which he piereed our Ship, and broke it off with striving to get loose, one of our Sailors dived and brought it aboard."

A half century later I find a reference in Catesby's work.[2]

Pennant, though aware of the statement made by Catesby, refuses the species a place in his "List of the Fishes of North America,"[3] supposing him to refer to the orca or high-finned killer-whale: "I am not certain whether *Catesby* does not mean the high-finned *Cachalot* by his Sword-fish; yet, as it is found in most seas, even to those of *Ceylon* (Mr. Sotur), I give it a place here."

Catesby's testimony was soon confirmed by Dr. Alexander Garden. This enthusiastic collector, through whose correspondence with Linnæus so many of our Southern plants and animals were first brought to knowledge and named, writes to John Ellis, from Charleston, South Carolina, March 25, 1755: "I have sent you one of the rostrums of a fish found on the Florida coast, which I take to be a species of the *Ziphias rostr. apice ensiforme, pinnis ventralibus nullis*.[4] I have been told that they are frequently found on the Carolina coast, though I have never seen any of them, and I have been all along the coast to the Florida shore."[5] (Vol. i, p. 353.)

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[1] For this fact, which I do not remember to have ever seen on record, I am indebted to Col. N. D. Wilkins, of the Detroit Free Press, who visited the locality in 1879.

[2] Historia Naturalis Carolinæ, &c., 1731.

[3] Arctic Zoology, iii, 1784, p. 364.

[4] The name by which this fish was designated in the earlier editions of Linnæus's writings.

[5] A Selection of the Correspondence of Linnæus and other Naturalists, from the original manuscripts. By Sir James Edward Smith, M. D., F. R. S., &c., president of the Linnæan Society. In two volumes. London. Printed for Longman, Hurst, Rees, Orme and Brown, Paternoster Row, 1821.

Another allusion occurs in a communication by Dr. S. L. Mitchill, of New York, to the "American Monthly Magazine":

"An individual of this species was taken off Sandy Hook, by means of a harpoon, on the 19th June, 1817. The next day it was brought to New York market and cut up like halibut and sturgeon for food. The length was about twelve feet, and girth, by estimation, five. . . . The stomach contained seven or eight mackerel. The flesh was remarkably firm; it was purchased at a quarter of a dollar the pound. I tasted a chop of it, broiled, and found it savory and excellent. It resembled the best sturgeon, without its strong and oily flavor. While I ate it I thought of veal cutlet. . . . I have been informed by my friend John Renny that a Sword-fish sixteen feet long was exhibited at New York in the year 1791."[1]

DISTRIBUTION IN THE EASTERN ATLANTIC.—The Sword-fish is abundant in the Mediterranean[2] even as far east as Constantinople. Ælian said that it was frequent in the Black Sea, entering the Danube. Unfortunately, this is neither confirmed nor contradicted by any later writer whose works I have seen. Ælian says that this species, with several others, is frequently taken in the Danube at the breaking up of the ice in spring. This is so contrary to the known habits of the fish that it throws discredit on the whole story, for the present at least. From the entrance to the Mediterranean they range south to Cape Town. Berthelot saw great numbers of them off the Canaries. They have been frequently noticed on the coasts of Spain and France. They occur sparingly in summer in the British waters, even to the Orkneys and the Hebrides. They occasionally reach Sweden and Norway, where Linnæus observed them, and, according to Lütken, have been taken on the coast of Finmark. They are known to have occurred in Danish waters and to have found their way into the Baltic, thus gaining a place in the fauna of Russia. A number of instances of the occurrence of Sword-fish in the Baltic have been recorded.

DISTRIBUTION ON THE COAST OF THE UNITED STATES.—Allusion has been made to the early accounts of the Sword-fish on the coast of the United States both in the work of Catesby and the letters of Garden to Ellis and Linnæus; also, to Mitchill's account of it in 1818. Though it is strange that this very conspicuous species was not recorded more frequently by early American authors, it is still more remarkable that its right to a place in the fauna of the Western Atlantic was either denied or questioned, as late as 1836, by such well-informed authors as Sir John Richardson and MM. Cuvier and Valenciennes.

Storer's "Report on the Ichthyology and Herpetology of Massachusetts," published in 1839, was the first American faunal list, after Catesby's, in which the Sword-fish was mentioned among the American fish.

The range of the species on the eastern coast of America can now be defined with some accuracy. Northward and eastward these fish have been seen as far as Cape Breton and Sable Island Banks.

Captain Rowe states that during a trip to George's Banks he has seen them off Chebucto Head, near Halifax, where the fishermen claim occasionally to have taken them with seines.

Capt. Daniel O'Brien, of the schooner "Ossipee," took five Sword-fish on his halibut trawl, in two hundred fathoms of water, between La Have and Brown's Banks, in August, 1877.

Capt. Jerome B. Smith, of the schooner "Hattie Lewis," of Gloucester, killed a Sword-fish off Cape Smoke, near Sidney, Cape Breton.[3]

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[1] American Monthly Magazine, ii, 1818, p. 242.
[2] Risso, Cuvier and Valenciennes, Guichenot, etc.
[3] Capt. R. H. Hulbert.

Mr. J. Matthew Jones, of Halifax, Nova Scotia, writes, in 1877: "The Sword-fish is by no means common on our coast, and only makes its appearance at intervals in our harbors and bays. One was taken in 1864 in Bedford Basin, at the head of Halifax Harbor. September 6, 1866, an individual weighing two hundred pounds was taken in a net at Devil's Island. November 12, 1866, the Rev. J. Ambrose sent me a sword, three feet and six inches long, from a fish taken at Dover, Nova Scotia, a few days previously."

On the coasts of Maine, Massachusetts, and Rhode Island they abound in the summer months. Southward they are less frequently seen, though their occurrence off New York is not unusual. I have never known one to be taken off New Jersey, and in our southern waters they do not appear to remain. Uhler and Lugger vaguely state that they sometimes enter the Chesapeake Bay.[1] This is apparently traditionary evidence.

Dr. Yarrow obtained reliable information of their occasional appearance near Cape Lookout, North Carolina.[2]

Mr. A. W. Simpson states, in a letter to Professor Baird, that Sword-fish are sometimes seen at sea off Cape Hatteras, in November and December, in large quantities. They sometimes find their way into the sounds.

An item went the rounds of the newspapers in 1876 to the effect that a Sword-fish four feet long had been captured in the Saint John's River, near Jacksonville. After personal inquiry in Jacksonville, I am satisfied that this was simply a scabbard-fish or silvery hair-tail (*Trichiurus lepturus*).

Professor Poey states that the fishermen of Cuba sometimes capture the *Pez de Espada* when in pursuit of *Agujas* or Spear-fishes.[3] They have also been seen in Jamaica.

Lütken gives instances of the capture of young Sword-fish at various points in the open Atlantic, as follows:

(1) Latitude 32° 50′ N., longitude 74° 19′ W. (about 150 miles southeast of Cape Hatteras).

(2) Latitude 23° W., longitude 55° W. (about 500 miles northeast of the island of Antigua).

(3) Latitude 20° N., longitude 31° W. (about 150 miles northwest of Teneriffe, and 250 southwest of Madeira).

(4) On the equator, longitude 29° (about 500 miles northeast of Cape St. Roque).

(5) Latitude 25° 4′ S., longitude 27° 26′ W. (about 500 miles south of the island of Trinidad, South Atlantic).

Occurrence in the Pacific and Indian Oceans.—We have no record of their occurrence on the eastern coast of South America, but the species is found on the Pacific coast of the same continent, and north to California.

Professor Jordan writes: "Occasionally seen about Santa Catalina and the Coronados, but never taken, the fishermen having no suitable tackle. One seen by us off Santa Monica, in 1880, about eight feet in length."

Mr. Willard Nye, of New Bedford, Massachusetts, kindly communicates the following notes: Captain Dyer, of this port, says that Sword-fish are plentiful off the Peruvian coast, a number being often in sight at one time. The largest he ever saw was one caught by himself about 150 miles from the shore, and which he estimates to have weighed 900 to 1,000 pounds; the ship's crew subsisted on it for several days and then salted 400 pounds.

[1] List of the Fishes of Maryland. By P. R. Uhler and Otto Lugger, in Report of the Commissioners of Fisheries of Maryland, January, 1876, p. 90.

[2] Notes on the Natural History of Fort Macon, North Carolina, and vicinity (No. 3). By H. C. Yarrow, in Proceedings of the Academy of Natural Sciences of Philadelphia, 1877, p. 207.

[3] Synopsis Piscium Cubensium, Catálogo razonado de los Peces de la Isla de Cuba, in Repertorio físico-natural de la Isla de Cuba, ii, 1868, p. 379.

Captain Allen also states that while cruising in the Pacific for whales he has found the Sword-fish very abundant on the coasts of Peru and Chili, from the immediate coast 300 miles out, though outside of that limit they are seldom seen. They are most plenty during the month of January, when they are feeding on the common mackerel, with which those waters at that time abound. The largest he ever caught weighed about 600 pounds.

Both Captain Allen and Captain Dyer have made several voyages as masters of whaling ships, and are perfectly familiar with Sword-fish on our coast; both speak of seeing plenty of *Bill-fish in the Pacific, but they never had taken the trouble to catch them.* Günther mentions them in his book on the "Fishes of the South Sea."

In 1874 Dr. Hector discovered a sword-fish snout in the museum at Auckland, New Zealand, and his announcement of the discovery was followed by the publication of two other instances of its occurrence in this region.[1]

SWORD-FISH ENTERING RIVERS.—Sword-fish have been known to enter the rivers of Europe. We have no record of such a habit in those frequenting our waters.[2]

Ælian's improbable story that they were taken in the Danube in winter has been mentioned. Southey and others relate that a man was killed while bathing in the Severn, near Worcester, by one of these fishes, which was afterwards caught.

Couch states that a Sword-fish, supposed to weigh nearly three hundred pounds, was caught in the river Parret, near Bridgewater, in July, 1834.[3]

According to De la Blanchere, one of them was taken, in the ninth year of the French Republic, in the river of Vannes, on the Bay of Biscay.[4]

In the great hall of the *Rathhaus* in the city of Bremen hangs a large painting of a Sword-fish which was taken in the river Weser by some Bremen fishermen some time in the eighteenth century.

Underneath it is painted the following inscription:

"ANNO. 1696. DEN. 18. JULI. IST. DIESER.
FISCH. EIN. SCHWERTFISCH. GENANNT. VON. DIESER.
STADT. FISCHERN. IN. DER. WESER. GEFANGEN.
UND. DEM. 20. EJUSDEM. ANHERO. NAEHER.
BREMEN. GEBRACHT. WORDEN. SEINE. GANZE.
LENGTE. WAR. 10. FUSS. DAS. SCHWERT. WAR.
7½. VIRTEL. LANG. UND. 3. ZOLL. BREIT."

PERIODICAL MOVEMENTS OF THE SWORD-FISH—TIMES OF ARRIVAL AND DEPARTURE.—Before entering upon a discussion of the movements of the Sword-fish and their causes, it

[1] HECTOR: Trans. New Zealand Inst., vii (1874), 1875, p. 246. HUTTON: *Ibid.*, viii (1875), 1876, p. 211. CHEESEMAN: *Ibid.*, p. 219.

[2] They sometimes approach very near the shore, however, as is shown by the following extract from a Cape Cod paper:

"*A Sword-fish in close quarters.*—Monday afternoon, while Mr. A. McKenzie, the boat-builder on J. S. Atwood's wharf, was busily at work, his attention was attracted by a splashing of water under his workshop, as if a score of boys were swimming and making all the noise they possibly could by beating the water with their feet and hands. After this had been kept up awhile his curiosity became excited, and upon investigating the cause of the disturbance discovered a Sword-fish among the piles, where, in his attempts to escape, he had become bewildered and imprisoned. Quickly getting a harpoon, Mr. McKenzie fastened the fish, and with the aid of bystanders drew it alive upon the wharf, where it was visited by many spectators, and subsequently dressed and sold. It measured ten feet from the end of its sword to the tip of the tail—the sword itself being three feet in length. It is the first instance known of one of these fish being so near the shore, and why it should have been there at the time described is not easily explained."—*Provincetown Advocate*, September 29, 1875.

[3] History of British Fishes, ii, p. 148.

[4] Dictionnaire Général des Pêches.

seems desirable to bring together the facts which have been learned, by conversation with fishermen and otherwise, in one group. Each man's views are given in his own style, and as nearly as possible in his own words. There is no attempt at a classification of the facts. This will be made subsequently.

An old sword-fish fisherman at New York informed Mr. Blackford that the season opens in the neighborhood of Sandy Hook about the first of June and continues along the coast as far east as Martha's Vineyard and Nantucket Shoals until about the middle of September. He has heard of their being caught as far east as Cape Sable. At the first cold winds of September they disappear. They are, like the mackerel, at first very poor and lean, but as the season advances they grow fatter.

Mr. John H. Thomson, of New Bedford, who kindly interviewed some of the local fishermen, writes: "The Sword-fish appear on our coast, south of Block Island, about May 25 to June 1. They appear to come from the southwest, or just inside the track of the Gulf Stream. They gradually approach the Vineyard Sound and vicinity during June, and until July 10 or 15, then appear to leave, working to the southeast, and are to be found to the southeast of Crab Ledge about the middle of July. This school is composed of comparatively small fish, averaging about one hundred and fifty pounds gross, or about one hundred pounds without head and tail, as they are delivered in the market. The smallest are four feet long, including the sword, and weigh from thirty to forty pounds; the largest eight and a half feet long, with sword, and weighing three hundred pounds gross. These fish are of a light plumbeous hue, darker on the back and white on the belly.

"Of late years another school has appeared southeast of Cape Cod and George's Banks about the 1st of August. These fish are altogether different, being much larger, weighing from three to eight hundred pounds gross, and are entirely black. I have this week conversed with an old smackman, M. C. Tripp, who has all his life been a fisherman, and has this year (1874) captured about ninety fish, and his opinion is that they are not the same school. They appear to be of about the same abundance in average years, the catch depending on weather, fogs, etc. They come and leave in a general school, not in close schools like other fish, but distributed over the surface of the water, the whole being called by the fishermen the 'annual school,' though it cannot strictly be so named."

According to Mr. Willard Nye, Sword-fish appear on the coast of Massachusetts from the 8th to the 20th of June, and are first seen southwest of Block Island. They begin to leave in August, but stray ones are sometimes seen as late as the last of October. The usual explanation of their movements is that they are following their food—mackerel and menhaden—which swarm our waters in the season named, and which are of course driven off by the approach of winter and rough weather.

Capt. R. H. Hurlbert took a very large Sword-fish on George's Banks, in November, 1875, in a snow-storm.

The first Sword-fish of the season of 1875 was taken June 20, southwest of Montauk Point; its weight was one hundred and eighty-five pounds.

One taken off Noman's Land, July 20, 1875, weighed when dressed one hundred and twenty pounds, and measured seven feet. A cast was taken (No. 360), which was exhibited in the Government Building at Philadelphia.

Capt. Benjamin Ashby, of Noank, Connecticut, tells me that the New London and Noank vessels leave home on their sword-fishing cruise about the 6th of July. Through July they fish between Block Island and Noman's Land; in August between Noman's Land and the South

Shoals light-ship. The fish "strike in" to Block Island and Montauk Point every year about the 1st of July. They are first seen twenty to twenty-five miles southeast of Montauk. At the end of August they are most abundant in the South Channel. Captain Ashby never saw them at any time so abundant as August 15, 1859. He was cruising between George's Banks and the South Shoals. It was a calm day, after a fog. He could at any time see twenty-five or thirty from the mast-head. They turn south when snow comes.

Capt. George H. Martin, of East Gloucester, tells me that the Gloucester vessels employed in this fishery expect to be on the fishing grounds south of George's Banks by the 10th of June. They almost always find the fish there on their arrival, following the schools of mackerel. They "tend on soundings," like the mackerel. The first Sword-fish of 1877 was taken June 10; the first of 1878, June 14.

The statements already quoted, and numerous conversations with fishermen not here recorded, lead me to believe that Sword-fish are most abundant on the shoals near the shore and on the banks during the months of July and August; that they make their appearance on the frequented cruising grounds between Montauk Point and the eastern part of George's Banks some time between the 25th of May and the 20th of June, and that they remain until the approach of cold weather in October or early in November. The dates of the capture of the first fish on the cruising ground referred to are recorded for three years, and are reasonably reliable: 1875, June 20; 1877, June 10; 1878, June 14.

South of the cruising ground the dates of arrival and departure are doubtless farther apart; north and east the season being shorter. There are no means of obtaining information, since the men engaged in this fishery are the only ones likely to remember the dates when the fish are seen.

REASONS OF THE COMING OF SWORD-FISH UPON OUR COAST.—The Sword-fish comes into our waters in pursuit of its food. At least this is the most probable explanation of their movements, since the duties of reproduction appear to be performed elsewhere. Like the tunny, the blue-fish, the bonito, and the squeteague, they pursue and prey upon the schools of menhaden and mackerel which are so abundant in the summer months. "When you see Sword-fish, you may know that mackerel are about," said an old fisherman to me. "Where you see the fin-back whale following food, there you find Sword-fish," said another. The Sword-fish also feeds upon squid, which are at times abundant on our banks.

THE INFLUENCE OF TEMPERATURE UPON THE MOVEMENTS OF THE SWORD-FISH.—To what extent this fish is amenable to the influences of temperature is an unsolved problem. We are met at the outset by the fact that they are frequently taken on trawl-lines which are set at the depth of one hundred fathoms or more, on the off-shore banks. We know that the temperature of the water at those localities and at that depth is sure to be less than 40° Fahrenheit. How is this fact to be reconciled with the known habits of the fish, that it prefers the warmest weather of summer and swims at the surface in water of temperature ranging from 55° to 70°, sinking when cool winds blow? The case seemed clear enough until this inconvenient discovery was made, that Sword-fish are taken on bottom trawl-lines. In other respects their habits agree closely with those of the mackerel tribe, all the members of which seem sensitive to slight changes in temperature, and which, as a rule, prefer temperature in the neighborhood of 50° or more.

There is one theory by which this difficulty may be avoided. We may suppose that the Sword-fish take the hooks on their way down to the bottom; that in their struggles they get entangled in the line and hooks, and when exhausted sink to the bottom. This is not improbable. A conversation with some fishermen who have caught them in this way develops the fact that the fish are usually much tangled in the line, and are nearly lifeless when they are brought to the

surface. A confirmation is found in the observations of Captain Baker, of the schooner "Peter D. Smith," of Gloucester, who tells me that they often are taken on the hand-lines of the cod-fishermen on George's Banks. His observations lead him to believe that they only take the hook when the tide is running very swiftly and the lines are trailing out in the tideway at a considerable distance from the bottom, and that the Sword-fish strike for the bottom as soon as they are hooked. This theory is not improbable, as I have already remarked, but I do not at present advocate it very strongly. I want more facts before making up my own mind. At present the relation of the Sword-fish to temperature must be left without being understood.

The appearance of the fish at the surface depends apparently upon temperature. They are seen only upon quiet summer days, in the morning before ten or eleven o'clock, and in the afternoon about four o'clock. Old fishermen say that they rise when the mackerel rise, and when the mackerel go down they go down also.

PROBABLE WINTER HABITAT OF THE SWORD-FISH.—Regarding the winter abode of the Sword-fish conjecture is useless. I have already discussed this question at length with reference to the menhaden and mackerel. With the Sword-fish the conditions are very different. The former are known to spawn in our waters, and the schools of young ones follow the old ones in toward the shores. The latter do not spawn in our waters. We cannot well believe that they hibernate, nor is the hypothesis of a sojourn in the middle strata of mid-ocean exactly tenable. Perhaps they migrate to some distant region, where they spawn. But then the spawning time of this species in the Mediterranean, as is related in a subsequent paragraph, appears to occur in the summer months, at the very time when Sword-fish are most abundant in our own waters, apparently feeling no responsibility for the perpetuation of their species.

MOVEMENTS OF INDIVIDUAL SWORD-FISHES.—A Sword-fish when swimming near the surface usually allows its dorsal fin and the upper lobe of its caudal fin to be visible, projecting out of the water several inches. It is this habit which enables the fisherman to detect the presence of the fish. It swims slowly along, and the fishing schooner with a light breeze finds no difficulty in overtaking it. When excited its motions are very rapid and nervous. Sword-fish are sometimes seen to leap entirely out of the water. Early writers attributed this habit to the tormenting presence of parasites, but this theory seems hardly necessary, knowing what we do of its violent exertions at other times. The pointed head, the fins of the back and abdomen snugly fitting into grooves, the absence of ventrals, the long, lithe, muscular body, sloping slowly to the tail, fit it for the most rapid and forcible movement through the water. Prof. Richard Owen, testifying in an English court in regard to its power, said:

"It strikes with the accumulated force of fifteen double-handed hammers. Its velocity is equal to that of a swivel-shot, and is as dangerous in its effects as a heavy artillery projectile."

Many very curious instances are on record of the encounters of this fish with other fishes, or of their attacks upon ships. What can be the inducement for it to attack objects so much larger than itself it is hard to surmise. Many are familiar with the couplet from Oppian:

> Nature her bounty to his mouth confined,
> Gave him a sword, but left unarmed his mind.

It surely seems as if a temporary insanity sometimes takes possession of the fish. It is not strange that, when harpooned, it should retaliate by attacking its assailant. An old sword-fish fisherman told Mr. Blackford that his vessel had been struck twenty times. There are, however, many instances of entirely unprovoked assault on vessels at sea. Many of these are recounted in a later portion of this memoir. Their movements when feeding are discussed below, as well as their alleged peculiarities of movement during the breeding season.

It is the universal testimony of our fishermen that two are never seen swimming close together. Captain Ashby says that they are always distant from each other at least thirty or forty feet.

MAXIMUM AND AVERAGE SIZE OF AMERICAN SWORD-FISH.—The only individual of which we have the exact measurements was taken off Seaconnet, Rhode Island, July 23, 1874. This was seven feet seven inches long, weighing 113 pounds. Another, taken off Noman's Land, July 20, 1875, and cast in plaster for the collection of the National Museum, weighed 120 pounds, and measured about seven feet. Another, taken off Portland, August 15, 1878, was 3,999 millimeters long, and weighed about 600 pounds. Many of these fish doubtless attain the weight of 400 and 500 pounds, and some, perhaps, grow to 600; but after this limit is reached, I am inclined to believe larger fish are exceptional. Newspapers are fond of recording the occurrence of giant fish, weighing 1,500 pounds and upwards, and old sailors will in good faith describe the enormous fish which they saw at sea, but could not capture; but one well-authenticated instance of accurate weighing is much more valuable. The largest one ever taken by Capt. Benjamin Ashby, for twenty years a sword-fish fisherman, was killed on the shoals back of Edgartown, Massachusetts. When salted it weighed 639 pounds. Its live weight must have been as much as 750 or 800. Its sword measured nearly six feet. This was an extraordinary fish among the three hundred or more taken by Captain Ashby in his long experience. He considers the average size to be about 250 pounds dressed, or 325 alive. Captain Martin, of Gloucester, estimates the average size at 300 to 400 pounds. The largest known to Captain Michaux weighed 625. The average about Block Island he considers to be 200 pounds.

There are other stories of large fish. Capt. R. H. Hurlbert, of Gloucester, killed one on George's Banks, in September, 1876, which weighed when dressed 480 pounds. Capt. John Rowe, of the same port, salted one which filled two and one-half barrels. This probably weighed 600 pounds when alive. I have been told that a Sword-fish loses one-third of its weight in dressing, but I should think that one-fourth would be nearer to the truth. Captain Baker, of the schooner "Peter D. Smith," of Gloucester, assures me that he killed, in the summer of 1874, off Portland, a Sword-fish which weighed 750 pounds.

Mitchill and DeKay state that in 1791 a Sword-fish sixteen feet in length was exhibited in New York. It is questionable whether they often exceed this measurement. My own observations have been made on specimens from seven to twelve feet long. A stuffed specimen in the United States National Museum measures about ten feet, and this seems to be very nearly the average size.

MINIMUM SIZE OF AMERICAN SWORD-FISH.—The size of the smallest Sword-fishes taken on our coast is a subject of much deeper interest, for it throws light on the time and place of breeding. There is some difference of testimony regarding the average size, but all fishermen with whom I have talked agree that very small ones do not find their way into our waters. I have collected several instances from the experiences of men long wonted to this fishery.

Capt. John Rowe has seen one which did not weigh more than 75 pounds when taken out of the water.

Capt. R. H. Hurlbert killed, near Block Island, in July, 1877, one which weighed 50 pounds, and measured about two feet without its sword.

Captain Ashby's smallest weighed about 25 pounds when dressed; this he killed off Noman's Land. He never killed another which weighed less than 100. He tells me that a Bridgeport smack had one weighing 16 pounds (or probably 24 when alive), and measuring eighteen inches without its sword.

In August, 1878, a small specimen of the mackerel shark, *Lamna cornubica*, was captured at the mouth of Gloucester Harbor. In its nostril was sticking the sword, about three inches long, of a young Sword-fish. When this was pulled out the blood flowed freely, indicating that the wound was recent. The fish to which this sword belonged cannot have exceeded ten or twelve inches in length. Whether the small Sword-fish met with its misfortune in our waters, or whether the shark brought this trophy from beyond the sea, is a question I cannot answer.

Lütken speaks of a very young individual taken in the Atlantic, latitude 32° 50′ N., longitude 74° 19′ W. This must be about 150 miles southeast of Cape Hatteras.

SIZE IN THE MEDITERRANEAN.—In the Mediterranean, near Sicily and Genoa, young fish, ranging in weight from half a pound to twelve pounds, are said to be abundant between November and March.

About La Ciotat and Martigues, in the south of France, many are taken too small to injure the fishing-nets, and very rarely reaching the weight of 100 pounds.

From the statements of Bloch and later writers it appears that large Sword-fish also are abundant in the Mediterranean. Late Italian fishery reports state that the average weight of those taken on the coast of Italy is 50 kilograms (110 pounds).

Of the coasts of Spain and Portugal Steindachner remarks: "More abundant on the southern coasts of Spain than on the northern, western, and eastern sides of the Iberian Peninsula. We saw quite large examples in the fish-markets at Gibraltar, Cadiz, Lisbon, La Coruña, and Barcelona, and at Santa Cruz, Teneriffe. The largest of three specimens in my possession is forty-three inches long, another twenty-four inches."[1]

RATE OF GROWTH.—Little is known about the rate of growth. The young fish taken in winter in the Mediterranean, ranging in weight from half a pound to twelve pounds, are thought to have been hatched during the previous summer. Those of a larger size, ranging from twenty-four to sixty pounds, taken on the New England coast in the summer, may perhaps be the young of the previous year. Beyond this, even conjecture is fruitless. As in other species, the rate of growth depends directly upon the quantity of food consumed. It is to be presumed that a summer passed in feasting among the crowding schools of menhaden and mackerel in our waters would bring about a considerable increase in weight. That this is the case is clearly shown by the testimony of the fishermen, who say that in the spring Sword-fish are thin, growing fatter and heavier as the season goes on.

Dr. Lütken and Dr. Günther have lately made some exceedingly interesting observations upon the young of the Sword-fish and of the Spear-fish and Sail-fish.

Dr. Günther's studies were made upon very small specimens of undetermined species, belonging to either *Tetrapturus*, *Histiophorus*, or both. In his latest work, "The Study of Fishes," he summarizes the facts observed by him as follows:

"The Sword-fishes with ventral fins (*Histiophorus*) belong to the Teleosteans of the largest size. In young individuals, nine millimeters long, both jaws are produced and armed with pointed teeth, the supraorbital margin is ciliated, the parietal and preoperculum are prolonged into long spines, the dorsal and anal fins are a long fringe, and the ventrals make their appearance as a pair of short buds. When fourteen millimeters long the young fish has still the same armature of the head, but the dorsal fin has become much higher, and the ventral filaments have grown to a great length. At the next stage, when the fish has attained to a length of sixty millimeters, the upper jaw is considerably prolonged beyond the lower, losing its teeth, the spines of the head are shortened, and the fins assume nearly the shape which they retain in mature individuals.

[1] Sitzungsb. d. k. Akad. d. Wissensch., Wein, 1868, p. 396.

"Young Sword-fishes without ventral fins (*Xiphias*) undergo similar changes, and, besides, their skin is covered with small, rough excrescences, longitudinally arranged, which continue to be visible after the young fish has attained the form of the mature in other respects."

Dr. Lütken's description of the young Sword-fishes is an exceedingly valuable contribution to knowledge.

I have collected together, in the plates which accompany this paper, the various published figures of young Sword-fishes, and have had them redrawn as nearly as possible to a uniform scale.

Of the Sword-fish, *Xiphias gladius*, two figures are given. One, taken from Lütken's "Spolia Atlantica," is thirty-seven millimeters long; the other is a reproduction of the often-copied figure in Cuvier and Valenciennes' "Histoire Naturelle des Poissons," twelve to eighteen inches long. Lütken had a similar specimen, ten millimeters long, but it was too poorly preserved to be figured.

Of the various species of *Tetrapturus* and *Histiophorus*, six figures are given. The smallest is that from "Spolia Atlantica," and is of a fish five and one-half millimeters long. Lütken remarks that he has a series from five and one-half to twelve millimeters long which differ very little from each other. The next in size is copied from Günther, and is probably about ten millimeters long; the third, also from Günther, is fourteen millimeters long. Lütken has another link in the series, a specimen twenty-one millimeters long, which he has not figured. The fourth stage is from Günther, a specimen sixty millimeters long; the fifth, from Cuvier and Valenciennes, their *Histiophorus pulchellus*, about four hundred and ten millimeters long; the sixth, from Rüppell, a copy of his figure of *H. immaculatus*, said to be about eighteen hundred millimeters long. These illustrations show the development in a very satisfactory manner.

ABUNDANCE AT PRESENT.—For many years from three to six thousand of these fish have been taken annually on the New England coast. It is not unusual for twenty-five or more to be seen in the course of a single day's cruising, and sometimes as many as this are visible from the mast-head at one time. Captain Ashby saw twenty at one time, in August, 1839, between George's Banks and the South Shoals. One Gloucester schooner, the "Midnight," Capt. Alfred Wixon, took fourteen in one day on George's Banks, in 1877.

Capt. John Rowe obtained twenty barrels, or four thousand pounds, of salt fish on one trip to George's Banks; this amount represents twenty fish or more.

Captain Ashby has killed one hundred and eight Sword-fish in one year; Capt. M. C. Tripp killed about ninety in 1874.

Such instances as these indicate in a general way the abundance of the Sword-fish. A vessel cruising within fifty miles of our coast, between Cape May and Cape Sable, during the months of June, July, August, and September, cannot fail, on a favorable day, to come in sight of several of them. Mr. Earll states that the fishermen of Portland never knew them more abundant than in 1879. This is probably, in part, due to the fact that the fishery there is of very recent origin.

ABUNDANCE IN THE PAST AND PROBABILITY OF FUTURE DECREASE.—There is no evidence of any change in their abundance, either increase or decrease. Fishermen agree that they are as plenty as ever, nor can any change be anticipated. The present mode of fishing does not destroy them in any considerable numbers, each individual fish being the object of special pursuit. The solitary habits of the species will always protect them from wholesale capture, so destructive to schooling fish. Even if this were not the case, the evidence proves that spawning Sword-fish do not frequent our waters. When a female shad is killed, thousands of possible young die also. The Sword-fish taken by our fishermen carry no such precious burden.

EFFECTS OF OVERFISHING IN THE MEDITERRANEAN.—A very different tale was once told of

the winter fishery in the Mediterranean. Meunier quotes this testimony by Spallanzani: "I took part many times in this fishery, and I dare not tell how many young fish are its victims; being of no value they are thrown back into the sea, mutilated or already dead from the rubbing of the net-meshes. I write denouncing this destructive method, and I urge forcibly the harm which results from it. They tell me it is true that there is a law of Genoa which forbids its use, or rather its abuse, but this does not do away with the fact that each year there sail from the Gulf of Spezzia three or four pairs of fishing boats which go to the sea to carry on this fishing. Still more, the governor of the place, who should carry out this law, is the first to favor, by means of a gift of silver, the abuse which it is intended to prevent."

This, however, was a century ago. I have met with no complaints of decrease in the works of later writers, though in Targioni-Tozzetti's report, published in 1880, it is stated that there is much opposition to the capture of small fish.

NATURE OF FOOD.—Dr. Fleming found the remains of Sepias in its stomach, and also small fishes. Oppian stated that it eagerly devours the *Hippuris* (probably *Coryphæna*).

A specimen taken off Seaconnet, July 22, 1875, had in its stomach the remains of small fish, perhaps *Stromateus triacanthus*, and jaws of a squid, perhaps *Loligo Pealii*.

Their food in the Western Atlantic consists for the most part of the common schooling species of fishes.

They feed on menhaden, mackerel, bonitoes, bluefish, and other species which swim in close schools. Their habits of feeding have often been described to me by old fishermen. They are said to rise beneath the school of small fish, striking to the right and left with their swords until they have killed a number, which they then proceed to devour. Menhaden have been seen floating at the surface which have been cut nearly in twain by a blow of a sword. Mr. John H. Thomson remarks that he has seen them apparently throw the fish in the air, catching them on the fall.

Capt. Benjamin Ashby says that they feed on mackerel, herring, whiting, and menhaden. He has found half a bucketful of small fish of these kinds in the stomach of one Sword-fish. He has seen them in the act of feeding. They rise perpendicularly out of the water until the sword and two-thirds of the remainder of the body are exposed to view. He has seen a school of herring crowding together at the surface on George's Banks as closely as they could be packed. A Sword-fish came up through the dense mass and fell flat over on its side, striking many fish with the sides of its sword. He has at one time picked up as much as a bushel of herrings thus killed by a Sword-fish on George's Banks.

REPRODUCTION.—But little is known regarding their time and place of breeding. They are said to deposit their eggs in large quantities on the coasts of Sicily, and European writers give their spawning time as occurring the latter part of spring and the beginning of summer. In the Mediterranean they occur of all sizes from four hundred pounds down, and the young are so plentiful as to become a common article of food. Except in this region the young are never taken; on our own coast, plentiful as they are, they are never seen less than three feet, and are usually much larger. M. Raynaud, who brought to Cuvier a specimen of *Histiophorus* four inches long, taken in January, 1829, in the Atlantic, between the Cape of Good Hope and France, reported that there were good numbers of young Sail-fish in the place where this was taken.[1]

Old fishermen who have taken and dressed them by the hundred assure me that they have never seen traces of spawn in them. The absence of young fish and spawning females on the coast of North America would indicate that they do not breed with us. Judging from the locations where young fish have been taken, it seems probable that they breed in the open ocean.

[1] CUVIER & VALENCIENNES: Hist. Nat. Poiss., viii, p. 305.

Meunier,[1] quoting Spallanzani, states that the Sword-fish does not approach the coast of Sicily except in the season of reproduction; the males are then seen pursuing the females. It is a good time to capture them, for when the female has been taken the male lingers near and is easily approached. The fish are abundant in the Straits of Messina from the middle of April to the middle of September; early in the season they hug the Calabrian shore, approaching from the north; after the end of June they are most abundant on the Sicilian shore, approaching from the south.

From other circumstances, it seems certain that there are spawning grounds in the sea near Sicily and Genoa, for from November to the 1st of March young ones are taken in the Straits of Messina, ranging in weight from half a pound to twelve pounds.

ABSENCE OF ORDINARY HABITS OF BREEDING SEASON AMONG OUR SWORD-FISH.—In the Mediterranean, as has been already stated, the very young fish are found from November to March, and here from July to the middle of September the male fish are seen pursuing the female over the shoals, and at this time the males are easily taken. Old sword-fish fishermen, Captain Ashby and Captain Kirby, assure me that on our coast, out of thousands of specimens they have taken, they have never seen one containing eggs. I have myself dissected several males, none of which were near breeding time. In the European waters they are said often to be seen swimming in pairs, male and female. Many sentimental stories were current, especially among the older writers, concerning the conjugal affection and unselfish devotion of the Sword-fish, but these seem to have originated in the imaginative brain of the naturalist rather than in his perceptive faculties. It is said that when the female fish is taken the male seems devoid of fear, approaches the boat, and allows himself easily to be taken; but, if this be true, it appears to be the case only in the height of the breeding season, and is easily understood. I cannot learn that two Sword-fish have ever been seen associated together in our waters, though I have made frequent and diligent inquiry.

There is no inherent improbability, however, in this story regarding the Sword-fish in Europe, for the same thing is stated by Professor Poey as the result of his studies upon the habits of *Tetrapturus*.

A curious fancy was prevalent in former days regarding an anatomical character of the Sword-fish. In an article by Mr. Dale in "Philosophical Transactions" (abridged edition, ii, p. 835), he remarks: "I cannot concede it to be consonant to that Care and Industry of Nature, in providing convenient Receptacles for preserving the *Fœtus;* neither is it agreeable to Reason to believe, that when Nature had provided an Uterus in all Animals, not only the Viviparous, and such as only cherish the Embryo in Utero, but in the Oviparous also and Insects, the *Eel* and the *Xiphia*, or Sword-fish, should be the only Animals without it."

ENEMIES AND FATALITIES: PUGNACITY.—The pugnacity of the Sword-fish has become a by-word. Without any special effort on my part the following instances of their attacks upon vessels have in the last six years found their way into the pigeon-hole labeled "Sword-fish."

Ælian says (b. xxxii, c. 6) that the Sword-fish has a sharp-pointed snout, with which it is able to pierce the sides of a ship and send it to the bottom, instances of which have been known near a place in Mauritania known as Cottè, not far from the river Lixus, on the African side of the Mediterranean. He describes the sword as like the beak of the ship known as the trireme, which was rowed with three banks of oars.

One of the earliest accounts is that given in the second part of vol. i, lib. ii, p. 89, 1615, of "Purchas his Pilgrimes":

"The sixth Circum-Navigation, by William Cornelison Schovten of Horne; who Sovthwards

[1] Les Grandes Pêches, p. 142.

from the Straights of Magelan in Tierra-Delfvogo, fovnd and discovered a new passage through the great Sovth-Sea, and that way sailed rovnd about the World," etc.

Off the coast of Sierra Leone:

"The fift of October we were vnder foure degrees seuen and twentie minutes, the same day about noone, there was such a noyse in the Bough of our Shippe, that the master, being behind in the Gallerie, thought that one of the men had fallen out of the Fore-ship, or from the Boe-sprit into the sea, but as hee looked out over the side of the Ship hee saw the Sea all red, as if great store of bloud had beene powred into it, whereat hee wondred, knowing not what it meant, but afterward hee found, that a great Fish or a Sea monster having a horne had therewith stricken against the ship with most great strength. For when we were in Porto Desire where we set the Ship on the Strand to make it cleane, about seven foot under water, before in the Ship, wee found a Horne sticking in the Ship, much like for thicknesse and fashion to a common Elephants tooth, not hollow, but full, very strong hard Bone, which had entered into three Plankes of the Ship, that is two thicke Plankes of greene and one of Oken wood, and so into a Rib, where it turned upward, to our great good fortune, for if it had entered between the Ribbes, it would happily have made a greater Hole and have brought both Ship and men in danger to be lost. It strucke at least halfe a foote deepe into the Ship and about half a foote without, where, with great force it was broken off, by reason whereof the great monster bled so much."

More than a century later C. Mortimer, M. D., records this experience:

"Mr. Bankley shewed me the *Horn* of a *Fish* that had penetrated above 8 inches into the Timber of a Ship and gave me the following Relation of it: 'His MAJESTY'S Ship *Leopard*, having been at the *West Indies* and on the Coast of *Guiney*, was ordered by Warrant from the Honourable *Navy-Board*, dated Aug. 18, 1725, to be cleaned and refitted at Portsmout for Channel-Service: Pursuant thereto, she was put into the great Stone-dock; and, in stripping off her Sheathing, the Shipwrights found something that was uncommon in her Bottom, about 8 Feet from her Keel, just before the Fore Mast; which they searching into, found the Bone or Part of the Horn of a Fish of the Figure here described; the Outside Rough not unlike *Seal-Skin;* and the End, where it was broken off shewed itself like coarse Ivory. The Fish is supposed to have followed the Ship, when under Sail, because the Sharp End of the Horn pointed toward the Bow: It penetrated with that Swiftness or Strength that it went through the Sheathing 1 Inch thick, the Plank 3 Inches thick, and into the Timber, 4½ inches.'"[1]

Don Joseph Cornide, in his "Ensayo de una Historia de los Peces de la Costa de Galicia," 1787:

"This fish is taken in the seas of Galicia, where it is more common toward the Rio de Vigo, where it is well known that the 'Balandia' (a small fishing vessel), of S. M. le Ardilla, was pierced in its side and sunk by the arm of one of these fishes, which is preserved in the Royal Cabinet of Natural History."

The following statement is from the note book of Professor Baird:

In 1871 the little yacht "Redhot," of New Bedford, was out sword-fish fishing, and a Sword-fish had been hauled in to be lanced, and it attacked the vessel and pierced the side so as to sink the vessel. She was repaired and used in the service of the Commission at Wood's Holl.

Couch quotes the personal statement of a gentleman, who says:

"We have had the pleasure of inspecting a piece of wood cut out of one of the fore planks of a vessel (the 'Priscilla,' from Pernambuco) through which was struck about eighteen inches of

[1] An account of the horn of a Fish struck several Inches into the side of a Ship, by C. Mortimer, M. D., F. R. S. Philos. Trans., xl, No. 461, p. 362, 1741. Abr. ed., ix, p. 72.

the bony weapon of the Sword-fish. The force with which it must have been driven in affords a striking exemplification of the power and ferocity of the fish. The 'Priscilla' is quite a new vessel. Captain Taylor, her commander, states that when near the Azores, as he was walking the quarter-deck at night, a shock was felt which brought all hands from below, under the impression that the ship had touched upon some rock. This was, no doubt, when the occurrence took place."

The New York Herald of May 11, 1871, states:

"The English ship 'Queensberry' has been struck by a Sword-fish, which penetrated to a depth of thirty inches, causing a leak which necessitated the discharge of the cargo."

The "London Daily News of December" 11, 1868, contained the following paragraph, which emanated, I suspect, from the pen of Prof. R. A. Proctor:

"Last Wednesday the court of common pleas—rather a strange place, by the by, for inquiring into the natural history of fishes—was engaged for several hours in trying to determine under what circumstances a Sword-fish might be able to escape scot-free after thrusting his snout into the side of a ship. The gallant ship 'Dreadnought,' thoroughly repaired and classed A1 at Lloyd's, had been insured for £3,000 against all the risks of the seas. She sailed on March 10, 1864, from Colombo, for London. Three days later the crew, while fishing, hooked a Sword-fish. Xiphias, however, broke the line, and a few moments after leaped half out of the water, with the object, it should seem, of taking a look at his persecutor, the 'Dreadnought.' Probably he satisfied himself that the enemy was some abnormally large cetacean, which it was his natural duty to attack forthwith. Be this as it may, the attack was made, and at four o'clock the next morning the captain was awakened with the unwelcome intelligence that the ship had sprung a leak. She was taken back to Colombo, and thence to Cochin, where she was hove down. Near the keel was found a round hole, an inch in diameter, running completely through the copper sheathing and planking.

"As attacks by Sword-fish are included among sea-risks, the insurance company was willing to pay the damages claimed by the owners of the ship if only it could be proved that the hole had really been made by a Sword-fish. No instance had ever been recorded in which a Sword-fish had been able to withdraw his sword after attacking a ship. A defense was founded on the possibility that the hole had been made in some other way. Professor Owen and Mr. Frank Buckland gave their evidence, but neither of them could state quite positively whether a Sword-fish which had passed its beak through three inches of stout planking could withdraw without the loss of its sword. Mr. Buckland said that fish have no power of 'backing,' and expressed his belief that he could hold a Sword-fish by the beak; but then he admitted that the fish had considerable lateral power, and might so 'wriggle its sword out of the hole.' And so the insurance company will have to pay nearly £600 because an ill-tempered fish objected to be hooked, and took its revenge by running full tilt against copper sheathing and oak planking."

"The Gloucester schooner 'Wyoming,' on a last trip to George's Banks," records the 'New York World' of August 31, 1875, "was attacked by a Sword-fish in the night-time. He assailed the vessel with great force, and succeeded in putting his sword through one of her planks some two feet, and, after making fearful struggles to extricate himself, broke his sword off, leaving it hard and fast in the plank, and made a speedy departure. Fortunate was it that he did not succeed in drawing out his sword, as the aperture would undoubtedly have made a leak sufficient to sink the vessel. As it was, she leaked badly, requiring pretty lively pumping to keep her free."

Another instance of a similar nature is this, which was recorded in the "Liverpool Mercury" about the year 1876:

"Mr. J. J. Harwood, master of the British brigantine 'Fortunate,' in dock at Liverpool, reports that whilst on his passage from the Rio Grande, when in latitude 20° 12′ north and longitude 47°

9′ west, this ship was struck by a large fish, which made the vessel shake very much. Thinking the ship had been merely struck by the tail of some sea-monster, he took no further notice of the matter; but, after discharging cargo at Runcorn, and coming into the Canada half-tide dock, he found one of the plank ends in the stern split, and on closer examination he discovered that a Sword-fish had driven his sword completely through the plank, four inches in thickness, leaving the point of the sword nearly eight inches through the plank. The fish in its struggle broke the sword off level with the outside of the vessel, and by its attack upon the ship lost nearly a foot length of the very dangerous weapon with which it was armed. There is no doubt that this somewhat singular occurrence took place when the vessel was struck as Captain Harwood describes."

In "Forest and Stream" of June 24, 1875, was recorded the following incident:

"On Wednesday of last week a Sword-fish attacked the fishing-boat of Capt. D. D. Thurlow while he was hauling mackerel-nets off Fire Island, thrust its sword clear through the bottom, and stuck fast, while the fishermen took several half-hitches around its body and so secured it. It was afterwards brought to Fulton Market, and found to weigh three hundred and ninety pounds. Its sword measured three feet and seven inches, and its entire length was over eleven feet. The stuffed skin will adorn the Central Park Museum."

In the "Landmark," of Norfolk, Virginia, February, 1876, was mentioned a similar occurrence:

"The brig 'P. M. Tinker,' Captain Bernard, previously mentioned as having arrived here from Richmond, leaking, for repairs, has been hauled up on the ways at Graves' ship-yard. On examination it was discovered that the leak was caused by a Sword-fish, the sword being found broken off forward the bands, about sixteen feet abaft the forefoot. The fish, in striking the vessel, must have come with great force, as the sword penetrated the copper sheathing, a four-inch birch plank, and through the timbers about six inches—in all about ten inches. It occurred on the morning of the 23d of December, when the brig was eighteen days out from Rio, and in the neighborhood of Cape Saint Roque. She was pumped about four o'clock in the morning, and found free of water. About six o'clock the same morning she was again pumped, when water was obtained, and on examination it was found that she had made ten inches of water. The men were kept steady at the pumps until her arrival at Richmond, and while there, and on her trip here."

Mr. Willard Nye, of New Bedford, Massachusetts, sends the following note:

"A few years ago Captain Dyer, of New Bedford, struck a Sword-fish, from a thirty-foot boat, forty miles southwest of Noman's Land, threw overboard the keg, tacked, and stood by to the windward of it. When nearly abreast of it the man at the mast-head called out, 'Why, here he is, right alongside.' The fish was then about ten feet from the boat, and swimming in the same direction, but when he got where he could see the splash of water around the bow he turned and struck the boat about two feet from the stern and just below the water-line. The sword went through the planking, which was of cedar an inch and three-quarters thick, into a lot of loose iron ballast, breaking off short at the fish's head. A number of boats, large and small, have been 'stove' by Sword-fish on our coast, but always after the fish had been struck."

A nameless writer in "Harper's Weekly," October 25, 1879, narrates these instances, for which I am unable to give the original authority:

"In a calm day in the summer of 1832, on the coast of Massachusetts, a pilot was rowing his little skiff leisurely along, when he was suddenly roused from his seat by a thrust from below by a Sword-fish, who drove his sharp instrument more than three feet up through the bottom. With rare presence of mind, with the butt of an oar he broke it off level with the floor before the fish had time to withdraw it. Fortunately, the thrust was not directly upward. Had it been so, the frail boat would have been destroyed.

"A Boston ship hauled up on the ways for repair, a few years since, presented the shank of a Sword-fish's dagger, which had been driven considerably far into the solid oak plank. A more curious affair was brought to light in 1725 in overhauling His Majesty's ship 'Leopard,' from the coast of Africa. The sword of this marine spearsman had pierced the sheathing one inch, next it went through a three-inch plank, and beyond that three inches and a half into the firm timber. It was the opinion of the mechanics that it would have required nine strokes of a hammer weighing twenty-five pounds to drive an iron bolt of the same dimensions to the same depth in the hull. Yet the fish drove it at a single thrust.

"On the return of the whale-ship 'Fortune' to Plymouth, Massachusetts, in 1827, the stump of a sword blade of this fish was noticed projecting like a cog outside, which, on being traced, had been driven through the copper sheathing, an inch board undersheathing, a three-inch plank of hard wood, the solid white-oak timber twelve inches thick, then through another two and a half inch hard-oak ceiling, and lastly penetrated the head of an oil-cask, where it stuck, not a drop of the oil having escaped."[1]

Such instances could be found by the score, if one had the time and patience to search. The thing happens many times a year, and nearly as often affords a text for some paragrapher or local editor.

ENEMIES.—Such a large animal as the Sword-fish can have but few antagonists whose attacks would be disastrous. The tunny or horse-mackerel, *Orcynus thynnus*, other Sword-fishes, and sharks are its only peers in size, and of these the sharks are probably its worst foes.

Capt. N. E. Atwood exhibited to the Boston Society of Natural History, December 7, 1864, the lower jaw of a large shark, taken at Provincetown, Massachusetts, in whose stomach nearly the whole of a large Sword-fish was found. Some ten or twelve wounds were noticed in the skin of the shark, giving an idea of the conflict. The shark was doubtless *Galeocerdo tigrinus*.

Couch was told by a sailor that he had watched with interest the anxious motions of one as it was followed closely and rapidly in all its turnings by a blue shark. Twice did it leap above the surface to escape the near approach of its pursuer, but with what success at last the observer had no opportunity of knowing.

Mr. John H. Thomson states that the Bill-fish (probably *Tetrapturus albidus*) is their especial enemy. Bill fish, six to twelve feet long, appear about the last of the season, and their appearance is a signal that the Sword-fish are about leaving.

INVERTEBRATE PARASITES OF THE SWORD-FISH.—Aristotle thus explains the leaping movements of the fish: "The tunny and the *Xiphias* suffer from the œstrus at the rising of the dog-star, for both these fish at this season have beneath their fins a little worm which is called œstrus, which resembles a scorpion, and is about the size of a spider; they suffer so much from this torment that the *Xiphias* leaps out of the sea as high as the dolphin, and in this manner frequently falls upon our ships."

This description of the parasite is somewhat vague; yet it is evident that allusion is made to one of the Lerneans or gill-lice, little crustaceans remotely resembling crabs and lobsters, which attach themselves to the gills and skin of many kinds of fishes, sucking the blood from their veins, and often causing death; dreadful to their victims as was their namesake, the fabled Lernean Hydra, to the Argives of old, and not to be destroyed by any piscine Hercules and Iolaus.

In one of the early volumes of the "Philosophical Transactions" is an account by S. Paulo Boccone of "an extraordinary *Sanguisuga*, or *Leech*, found sometimes sticking fast in the Fish called *Xiphias* or *Sword-fish*." It is described as "about four Inches long, the Belly of it white, cartilaginous and transparent, without Eyes or Head, but instead of a Head it had a hollow Snout,

encompassed with a very hard Membrane; which Snout it thrusts whole into the Body of the Fish, as strongly as an *Augre* is wound into a piece of Wood, and fills it full of Blood into the very Orifice." He names it "*Hirudo*" or "*Acus cauda utrinque pennata.*"[1]

A specimen taken off Seaconnet, July 22, 1875, had fluke-worms in the external coat of the stomach and in the air-bladder.

The Sword-fish is infested by many species of invertebrate parasites. Some hang on the gills, others fasten themselves to different parts of the alimentary canal—the œsophagus, the stomach, and the intestines; and others still bore into the flesh. Several species, as might be expected from the size of the fish, are among the giants of their races. All undoubtedly cause more or less pain to their host, but especially those which attach themselves to the gills, disturbing their action and destroying their substance.

The parasites of the Sword-fish, for convenience, may be classified in two groups, the worm-like parasites (*Helminthes*) and the crustacean parasites.

FISH-PARASITES—THE SUCKERS OR REMORAS.—Several species of "stay-ships" or "remoras" occur on our coast. The ordinary kinds, such as *Echeneis naucrates*, the one with a black stripe down its side and white corners to its caudal fin, appears to choose companionship with the sharks, while the oceanic species, *Remora squalipeta*, is most often found clinging to ships.

A third species, *Remora brachyptera*, is the particular parasite of the Sword-fish. I have several times identified specimens found attached to the fish, and have never known this species to be found on any other member of the family. It has never come to us, moreover, from locality and season which would be inconsistent with a theory that it had been brought near shore by a Sword-fish.

Still another, *Rhombochirus osteochir*, seems equally inseparable from *Tetrapturus albidus*. This fact is known to the Cuban fishermen, who call it by the name *Pega de las Agujas*—the parasite of the Spear-fish.

Perhaps the two species are not so steadfast in their likings that they will not change from *Xiphias* to *Tetrapturus*. My friend Professor Giglioli, of Florence, who speaks of *R. brachyptera* as a fish new to the Mediterranean, obtained from Taranto a specimen said to have been taken from the gills (operculum?) of *Tetrapturus belone*.

These parasites probably prefer to cling with their curious suckers to the hard exterior surface of the opercular flap of the Sword-fish.

SWORD-FISH AS AN ARTICLE OF FOOD.—"The small Sword-fish is very good meat," remarked Josselyn, in writing of the fishes of New England in the seventeenth century. Since Josselyn probably never saw a young Sword-fish, unless at some time he had visited the Mediterranean, it is fair to suppose that his information was derived from some Italian writer.

It is, however, a fact that the flesh of the Sword-fish, though somewhat oily, is a very acceptable article of food. Its texture is coarse; the thick, fleshy, muscular layers cause it to resemble that of the halibut in consistency. Its flavor is by many considered fine, and is not unlike that of the bluefish. Its color is gray. The meat of the young fish is highly prized on the Mediterranean, and is said to be perfectly white, compact, and of delicate flavor.[2] Sword-fish are usually cut up into steaks, thick slices across the body, and may be broiled or boiled.

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[1] Philosophical Transactions, Vol. II, p. 821.

[2] The flesh, which is much esteemed by the better classes at Palermo, is dressed in almost as many modes as that of the tunny, and fetches a higher price. During our sojourn there it was as two to one, the price of the first averaging fourpence per *rebolo*, while the *porομαι* of the latter were disposed of at twopence or twopence-halfpenny. The fiber is invitingly white, and the round segments look, as they lie in rows along the stalls, like so many fillets of veal. Four to six feet is the usual run of those taken off the Trinacrian coast and displayed in the fish-markets of Sicily.—BADHAM.

Considerable quantities of Sword-fish are annually salted in barrels in Portland, Gloucester, Boston, New Bedford, and New London. Sword-fish pickled in brine is in considerable demand in certain sections of the country, and particularly in Lower Connecticut Valley, where a barrel may be found in almost every grocery store. By many persons it is considered much more palatable than salted mackerel.

THE SAIL-FISH—HISTIOPHORUS AMERICANUS.

Strange as it may seem, the American species of *Histiophorus* has never been studied by an ichthyologist, and no attempt has ever been made to describe it or to compare it carefully with the similar species occurring in the Indian Ocean. The identity of the two has been assumed by Dr. Günther,[1] but since no American specimens have ever been seen by this authority, I hesitate for the present to follow his lead.

The history of the Sail-fish in ichthyological literature is as follows:

The first allusion to the genus occurs in Piso's "Historia Naturalis Brasiliæ," printed at Amsterdam in 1648. In this book[2] may be found an identifiable though rough figure of the American species, accompanied by a few lines of description, which, though good, when the fact that they were written in the seventeenth century is brought to mind, are of no value for critical comparison.

The name given to the Brazilian Sail-fish by Marcgrave, the talented young German who described the fishes in the book referred to, and who afterward sacrificed his life in exploring the unknown fields of American zoology, was *Guebucu brasiliensibus*. The use of the name *Guebucu* is interesting, since it gives a clew to the derivation of the name "Boohoo," by which this fish, and probably the Spear-fishes, are known to English-speaking sailors in the tropical Atlantic.

Sail-fishes were observed in the East Indies by Renard and Valentijn, explorers of that region from 1680 to 1720, and by other eastern voyagers. No species of the genus was, however, systematically described until 1786, when a stuffed specimen from the Indian Ocean, eight feet long, was taken to London, where it still remains in the collections of the British Museum. From this specimen M. Broussonet prepared a description, giving it the name *Scomber gladius*, rightly regarding it as a species allied to the mackerel.

In 1803 Lacépède established the genus *Histiophorus* for the reception of this species.

When Cuvier and Valenciennes published the eighth volume of their Natural History of Fishes, they ignored the name *gladius*, which had been given to the East Indian fish by Broussonet, redescribing it under the name *Histiophorus indicus*. At the same time they founded another species upon the figure in Piso's Natural History of Brazil, already mentioned. This they called *Histiophorus americanus*.

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[1] Catalogue of the Fishes in the British Museum, ii, 1860, p. 513.

[2] 1648. PISO and MARCGRAVE:

Historia Naturalis | Brasiliæ, | Auspicio et Beneficio | Illustriss. | Mauritii Com. Nassau | illius Provinciæ et Maris summi Præfecti Adornata: | In qua | Non tantum Plantæ et Animalia, sed et In- | digenarum morbi, ingenia et mores describuntur et | Iconibus quingentis illustrantur | (Elaborate engraved title-page, upon which the preceding inscription is inserted upon a scroll, the following upon a shell.) Lvgdvn Batavorum, | Apud Franciscum Hackium, | et | Amstelodami, | Apud Lud. Elzevirium. 1648. | 1 pp. (12), 122, (2), (8), 293, (7).

Second title.

Guilielmi Pisonis, M. D. | Lugduno-Batavi, | de Medicina Brasiliensi | Libri Quatuor: | I. De Aëre, Aquis & Locis | II. De Morbis Endemiis. | III. Venenatis & Antidotis. | IV. De Facultatibus Simplicium | et Georgi Marcgravi de Liebstad, | Misnici Germani, | Historiæ Rerum Naturalium | Brasiliæ | Libri octo: | Quorum | Tres priores agunt de Plantis. | Quartus de Piscibus. | Quintus de Avibus. | Sextus de Quadrupedibus & Serpentibus. | Septimus de Insectis. | Octavus de Ipsa Regione, & Illius Incolis. | Cum | Appendice de Tapuyis, et Chilensibus. | Ioannes de Læt, | Antwerpianus, | In ordinem digessit & Annotationes addidit, & varies ab Auctore | Omissa supplevit & Illustravit.

In a paper printed in 1833, Dr. Nardo, of Venice, proposed the establishment of a new genus allied to *Tetrapturus* and *Xiphias*, to be called *Skeponopodus*. In this he included the fish described by Marcgrave under the name *Skeponopodus guebucu*, and also a form observed by him in the Adriatic in 1829, which he called *S. typus*. I am not aware that ichthyologists have yet learned what this may have been.[1]

From the time of Marcgrave until 1872 it does not appear that any zoologist had any opportunity to study a Sail-fish from America, or even from the Atlantic; yet in Günther's "Catalogue" the name *H. americanus* is discarded and the species of America is assumed to be identical with that of the Indian Ocean.[2]

Günther restores Lacépède's name, *H. gladius*, for the Indian species. Possibly, indeed probably, this name will be found to include the Sail-fish of our own coast. At present, however, it seems desirable to retain a separate name. To unite species from widely distant localities without ever having seen them is very disastrous to a proper understanding of the problems of geographical distribution.

The materials in the National Museum consist of a skeleton and a painted plaster cast of the specimen taken near Newport, Rhode Island, in 1872, and a drawing made of the same, while fresh, by Mr. J. H. Blake.

The occurrence of the Sail-fish is, as has been already stated, very unusual. Marcgrave saw it in Brazil as early as 1648. Sagra and Poey mention that it has been seen about Cuba, and Schomburg includes it in his Barbados list. The specimen in the United States National Museum was taken off Newport, Rhode Island, in August, 1872, and given to Professor Baird by Mr. Samuel Powell, of Newport. No others were observed in our waters until March, 1878, when, according to Mr. Neyle Habersham, of Savannah, Georgia, two were taken by a vessel between Savannah and Indian River, Florida, and were brought to Savannah, where they attracted much attention in the market. In 1873, according to Mr. E. G. Blackford, a specimen in a very mutilated condition was brought from Key West to New York City.

MOVEMENTS OF SAIL-FISHES.—No observations have been made in this country, and recourse must be had to the statements of observers in the other hemisphere.

In the life of Sir Stamford Raffles there is the following account from Singapore, under date of November 30, 1822:

"The only amusing discovery we have recently made is that of a sailing fish, called by the natives *Ikan layer*, of about ten or twelve feet long, which hoists a mainsail, and often sails in the manner of a native boat, and with considerable swiftness. I have sent a set of the sails home, as they are beautifully cut and form a model for a fast-sailing boat. When a school of these are under sail together they are frequently mistaken for a fleet of native boats."

The fish referred to is in all likelihood *Histiophorus gladius*, a species very closely related to, if not identical with, our own.

THE SPEAR-FISH—TETRAPTURUS ALBIDUS.

This species appears to be limited to the waters of the Mediterranean. It was not noticed by Linnæus, or indeed by any of the binomial writers before Schneider. In his posthumous edition of the writings of Bloch, the latter has made reference to a figure and description in Duhamel, and has given to a fish, which he figures in Plate XXI of this work, the name *Xiphias imperator*.

[1] *Isis*, 1833, Heft iv, pp. 415–419.

[2] The specimens in the British Museum are catalogued as follows: *a*. Eight feet long; stuffed. Indian Ocean. Type of the species. *b*. Seven feet long; stuffed. Cape of Good Hope. *c*. Dorsal fin. N. S. Wales (?). Presented by Dr. G. Bennett. *d*. Snout; dried.

This name was rejected by Cuvier (Règne Animal, *l. c.*), and has not been recognized by later writers. It seems to me, however, that Schneider has, perhaps unintentionally, yet quite intelligibly, expressed the principal differential characters of *Tetrapturus*. By "*dorso scabro*" he covers the question of the scales; by "*carina caudali nulla*" he refers to the absence of the single caudal carina of *Xiphias*, while by figure and by implication in his description he admits the presence of ventral fins. His figure, though bad, is as good as most of the old figures of *Xiphias*—that in Lacépède, for example.

T. imperator is said to attain the length of five or six feet, and the weight of one hundred and fifty pounds. It has been taken in the Straits of Messina with the harpoon, but according to Rafinesque is very rarely seen on the coasts of Sicily, and then only in autumn, when it is following the dolphin and flying-fish, upon which it feeds. It is ordinarily seen in pairs, male and female together, and they are taken often in the nets together. Its flesh is white, but not particularly well flavored. At Messina it is called "*Aguglia imperiale*" (Cuvier and Valenciennes).

Two species have been described by Poey from Cuba, one of which, *T. albidus*, is not uncommon on the Atlantic coast of the United States. Lütken is disposed to consider them both identical with the *T. indicus* type, and it seems to me that there is as much reason for doing this as for throwing together the Sail-fishes of the Atlantic and Indian Oceans, as has been persistently done by all writers on ichthyology.

Many individuals are taken every year by the sword-fish fishermen of New England, and they also frequently find their way into the pounds along the coast.

MOVEMENTS OF SPEAR-FISHES.—The Spear-fish in our waters is said by the fishermen to resemble the Sword-fish in its movements and manner of feeding. Professor Poey narrates that both the Cuban species swim at a depth of one hundred fathoms, and they journey in pairs, shaping their course toward the Gulf of Mexico, the females being full of eggs. Only adults are taken. It is not known whence they come, or where they breed, or how the young return. It is not even known whether the adult fishes return by the same route. When the fish has swallowed the hook it rises to the surface, making prodigious leaps and plunges. At last it is dragged to the boat, secured with a boat-hook, and beaten to death before it is hauled on board. Such fishing is not without danger, for the Spear-fish sometimes rushes upon the boat, drowning the fisherman, or wounding him with its terrible weapon. The fish becomes furious at the appearance of sharks, which are its natural enemies. They engage in violent combats, and when the Spear-fish is attached to the fisherman's line it often receives frightful wounds from these adversaries.

In "Land and Water" for August 31, 1872, Col. Nicholas Pike, author of "Subtropical Rambles," at that time United States consul at Mauritius, describes the habits of a species of *Tetrapturus* occurring in that vicinity. He states that they have the habit of resting quietly on the surface in calm weather, with their dorsals expanded and acting as sails. They are taken in deep water with hook and line, or speared when near the surface, like Sword-fish. When hooked or speared they make for the boats, taking tremendous leaps in the air, and if care is not taken they will jump into the boats, to the great consternation of the fishermen, or else pierce the boats with their bills. The fish is highly esteemed in the Mauritius, the flesh being of a salmon-color near the vertebræ; lower down it is red and like coarse beef. The species attains a large size, one having been seen measuring twenty-six feet.

PUGNACITY OF THE SPEAR-FISH.—The Spear-fish strikes vessels in the same manner as the Sword-fish. I am indebted to Capt. William Spicer, of Noank, Connecticut, for this note:

"Mr. William Taylor, of Mystic, a man seventy-six years old, who was in the smack 'Evergreen,' Capt. John Appleman, tells me that they started from Mystic, October 3, 1832, on a fishing

voyage to Key West, in company with the smack 'Morning Star,' Captain Rowland. On the 12th they were off Cape Hatteras, the wind blowing heavily from the northeast, and the smack under double-reefed sails. At ten o'clock in the evening they were struck by a 'Woho' (*sic*), which shocked the vessel all over. The smack was leaking badly, and they made a signal to the 'Morning Star' to keep close by them. The next morning they found the leak, and both smacks kept off to Charleston. On arrival they took out the ballast, hove her out, and found that the sword had gone through the planking, timber, and ceiling. The plank was two inches thick, the timber five inches, and the ceiling one and a half inches white oak. The sword projected two inches through the ceiling, on the inside of the 'after-run.'[1] It struck close by a butt on the outside, which caused the leak. They took out and replaced a piece of the plank, and proceeded on their voyage."

J. Matthew Jones, esq., of Halifax, Nova Scotia, in his delightful little book "The Naturalist in Bermuda," records the case of the Bermudian schooner "Earl Dundonald," arrived in the port of Hamilton, which was pierced by one of these formidable fish off the coast of British Guiana.

In the museum of Charleston College, Charleston, South Carolina, is preserved a fragment of the snout of a Spear-fish, apparently *Tetrapturus albidus*. By the kindness of the curator, Dr. G. E. Manigault, I was allowed to examine it and copy the label, which reads as follows: "The brig 'Amsterdam,' bound to Charleston, owned by F. C. Bray, was struck in the Gulf Stream by a monster or Sword-fish, which caused the vessel to leak considerably. By great exertion she was kept free, and gained the port in safety."

Messrs. Foster, Waterman & Co., of Boston, presented to the Boston Society of Natural History, in 1869, a plank of Southern pine, from the side of the ship "Pocahontas," owned by them, perforated by and containing a portion of the sword of a "Sword-fish," probably a species of *Histiophorus*.[2]

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[1] A hold under the cabin.

[2] Proc. Bost. Soc. Nat. Hist., xiii, 1869, p. 64.

M.—THE TILE-FISH FAMILY, AND OTHERS.

112. THE TILE-FISH FAMILY—LATILIDÆ.

This family, which has some relations both with the perch-like fishes and with those of the mackerel tribe, although until within a few years not known to occur within the territory of the United States, is now coming into considerable prominence, and there is every reason to believe that some of its members will yet grow into such favor and be found so abundant as to rank among the important food-fishes of the United States. The most important is the Tile-fish, *Lopholatilus chamæleonticeps*, a form discovered on a hitherto unexplored ground, eighty miles southeast of Noman's Land, Massachusetts, in 1879, and in 1880 demonstrated by the explorations of the Fish Commission to be exceedingly abundant everywhere on the coast of Southern New England, at a depth of eighty to two hundred and fifty fathoms. This fish, which is one of the most brilliantly colored species known outside the tropics, is very remarkable by reason of the presence of a soft dorsal fin, resembling that of the salmon, which is placed upon the neck in advance of the regular dorsal fin, instead of behind it, as in the salmon family. Numerous specimens have been obtained, varying from ten to fifty pounds, and, although there has been no opportunity to study the breeding habits, there is every reason to believe that it is resident in our waters in precisely the same manner as the codfish. Its abundance is very great. Captain Kirby, of Gloucester, who was the first to obtain specimens of this fish, caught in a few hours several hundred, which he salted down like codfish. In September, 1880, a small boat, sent out from the Fish Commission steamer while it was dredging upon the "Tile-fish Ground," caught twelve large individuals on one short line, the aggregate weight of which cannot have been less than two hundred and fifty pounds. They were tasted at the ward-room table and the flesh was found to be fine-grained and delicate in flavor, resembling in some respects that of the cod, in others, that of the striped bass.

The habits and food of this fish are probably very similar to those of the codfish, and the ground upon which they are taken has been ascertained to be very richly supplied with all the forms of small marine life which occur on the best cod banks. In time these fish cannot fail to be the object of a popular demand, and the proximity of the grounds they inhabit to several large cities will greatly enhance the importance of the Tile-fish.

In the Gulf of Mexico there is a related species which has as yet no popular name, but which has been described under the binomial *Caulolatilus microps*, and which is occasionally taken on the snapper banks. This was first observed by Mr. Silas Stearns, who sent specimens to the National Museum. As yet only five specimens have been brought into Pensacola, all in March and April, 1879, these having been taken with hook and line in thirty-five fathoms of water off Pensacola. These fish range in weight from six to ten pounds. It is not yet known whether they are sufficiently abundant to be of commercial importance, though there can be no question regarding their edibility.

Another species, *Caulolatilus chrysops* (C. & V.) Gill, occurs in the Caribbean Sea and on the coast of Brazil, while other related forms are known in China and Japan and on the west coast of South America.

"In California," writes Professor Jordan, "there is a species, *Caulolatilus anomalus* (Cooper), Gill, very similar to that of the Gulf of Mexico, and of some prominence as a food-fish, and known as the 'White-fish' or 'Blanquillo.' It reaches a length of about thirty inches and a weight of ten or fifteen pounds, though its average weight is four or five pounds. It ranges from Monterey southward to Mexico, being very abundant about the Santa Barbara Islands. It lives about rocks in water of considerable depth and takes the hook freely. Its food consists of crustaceans and fishes; it is considered to be a fish of fair but not excellent quality when fresh. When salted and dried it is graded as first quality with the barracuda and the yellow-tail. South of Point Concepcion it is one of the most important food-fishes, but is rarely sent to the market of San Francisco."

An allied form is *Bathymaster signatus* Cope, the "Ronchil," found in deep water from Puget Sound northward.

113. THE RED MULLET FAMILY—MULLIDÆ.

This family is represented in our waters by a single species, *Upeneus flavovittatus*, which has been observed in two or three instances on the coast of Southern New England, and is doubtless an estray from the West Indies. It has not yet been brought to light on the Gulf coast of the United States. A closely related species is the Mullet or Surmullet of Europe, the Mullus of the ancient Romans, highly prized by them. This fish was brought living into the banquet-hall that the guests might admire the brilliant changes of color exhibited in its expiring struggles.

Another species of this family is occasionally taken at Pensacola, but is not sufficiently abundant to possess any considerable economic importance.

114. THE ICOSTEUS FAMILY.

This family consists of two small fishes, peculiar to our California coast, which live in considerable depths of water: *Icichthys Lockingtoni* J. & G., only one specimen of which is known; and *Icosteus ænigmaticus* Lockington, likewise rarely taken, and only in deep water.

In the last two species the skeleton is scarcely ossified, and the body is as limp as a rag.

115. THE BERYX FAMILY—BERYCIDÆ.

Of this family, which is widely distributed throughout the temperate and tropical seas, and which has many representatives in the deeper parts of the ocean, only one species here appropriate to be mentioned occurs upon our coast, viz, the Bermuda "Squirrel-fish," *Holocentrum pentacanthum*. This fish ranges south to Brazil, east to the Bermudas, and is very abundant in the West Indies. Professor Gill has recorded the capture of a specimen at Newport, Rhode Island, in 1873. It is abundant on the Florida coast south of Cedar Keys, a few being found, as stragglers, north and west of that limit. It is caught with hook and line in all the channels and on the reefs. Stearns obtained several specimens at Pensacola Bay in 1876 and in 1882. He testifies that he has eaten them frequently and that they are as good a pan-fish as any on the coast. They attain a length of twelve to fifteen inches. About the Bermudas they are very abundant, and are conspicuous on account of their brilliant red hue and their habit of skulking in holes about the reefs. They feed upon small fishes and breed abundantly, apparently spawning in the summer season. At Cuba this fish is called the "Matajuelo."

N.—THE DRUM FAMILY.

The family *Sciænidæ* is distributed along the coasts of temperate and tropical countries the world over, though most abundant in the Western Atlantic, the Eastern Pacific, and Indian Oceans, and in the Mediterranean Sea. Many of the species are most abundant about the mouths of rivers, and there are several species, such as the fresh-water Drum, *Haploidonotus grunniens*, of the Mississippi Valley, which are found only in fresh water. In general form many of the members of this family are not unlike the salmon, and are sometimes mistaken for this fish. They are, however, true spiny-rayed fishes. The Drum and its congeners may be distinguished *from all others by the presence of the comparatively short, spiny dorsal fin, and a very long,* soft-rayed fin upon the posterior portion of the back.

Many of them are ground-loving species, and are provided with barbels by which they feel their way over the bottom, and with strong, pavement-like teeth for crushing shell-fish and strong shelled crustaceans. To this group belong the fresh-water Drum, the King-fish, and others.

Another group, typified by the Squeteagues, are without the barbels and possess long, sharp teeth, being surface feeders, rapid swimmers, and voracious.

The Red Drum of our coast, *Sciæna ocellata*, resembles in some respects both of these groups. Nearly all the members of this family have the power of uttering loud sounds. This, as has been demonstrated by M. Dufossé, is accomplished through a peculiar structure of the air-bladder.

116. THE SQUETEAGUE—CYNOSCION REGALE.

NAMES.—This well-known fish is one of those which bear a great variety of names. About Cape Cod they are called "Drummers"; about Buzzard's Bay and in the vicinity the largest are known as "Yellow-fins"; in New York and in New Jersey, "Weak-fish"; from Southern New Jersey to Virginia, "Bluefish." The name "Squeteague" is of Indian origin, and "Squit," "Succoteague," "Squitee," and "Chickwit" are doubtless variations of this name in different ancient and modern dialects. In the Southern Atlantic States it is called "Grey Trout," "Sun Trout," and "Shad Trout," and with the other members of the genus is spoken of under the name "Sea Trout" and "Salt-water Trout," though, of course, distinct from the "trout" of the fresh waters of the South, the large-mouth Black Bass. The name "Squeteague," since it is the aboriginal Indian name, seems most characteristic, and is well worthy of being permanently retained.

ABUNDANCE.—The Squeteague is found on the Atlantic coast from Cape Cod to Eastern Florida, where I observed it sparingly in 1878. Its extreme southern distribution has not yet been indicated. Some writers have claimed that it occurs at New Orleans, but Mr. Stearns did not succeed in finding it in the Gulf, and Professor Jordan writes that it is certainly not found in the Gulf of Mexico, unless as a stray.

The Squeteague is abundant throughout the above range, except in the regions where its productiveness is interfered with by the bluefish. In Massachusetts Bay, according to Dr. Storer, it is very rare, but scattering individuals have been found as far north as the Bay of Fundy. The early annals of New England make frequent mention of this fish and of its variations in number with that of the bluefish. Thus, according to Dr. Storer, it was very abundant in the Vineyard Sound in the early part of the present century, but gradually became more scarce, until about

1870, when it was no longer to be met with, and for several years it was entirely unknown in these waters; so much so, indeed, that fishermen of many years' experience were totally unacquainted with its characteristics. In 1867 or 1868, however, scattering individuals were taken on the south coast of Massachusetts, and in 1870 they were quite abundant and have since held their own.[1]

This variation in their numbers is ascribed by writers generally to the action of the bluefish, which, by its constant attacks, is supposed to influence their abundance. Some cause or other produced a similar influence upon the bluefish, which became scarce in turn; thus the Squeteague was enabled to recover its ground, and to resume its place in the food economy of the coast. To what extent this disappearance or reappearance of the Squeteague is actually connected with that of the bluefish, it is impossible at present to state. It is quite likely that other causes, at least, are concerned, with which we are now unacquainted.

We have intimations, in the writings of the early historians of New England, of the disappearances and returns of the Weak-fish, like those referred to in the present century.

The Squeteague, as well as the bluefish, varies in size with the locality. While on the coast of New Jersey they do not average much over one pound, they are stated to occasionally attain the weight of from six to ten pounds, and have even been known to weigh thirty.

Although essentially a coast and still-water fish, they occasionally run up tidal waters, and are thought on the coast of New Jersey to prefer the vicinity of the mouths of fresh-water streams, where they can find a mixture of fresh water. In the vicinity of Beasley's Point, where at times, in consequence of drought, there is more fresh water brought down into Egg Harbor than usual, they are known to move to a considerable distance up towards the headwaters, and to leave, to a great measure, their ordinary grounds more seaward.

The Squeteague in the South is a resident fish, although said by Holbrook to be most abun-

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[1] A GREAT CATCH OF FISH—WHAT THREE STEAM SMACKS CAUGHT OFF ROCKAWAY.—A great catch of Weak-fish was made yesterday about two miles off Rockaway Beach, by the steam smacks "E. T. De Blois," Capt. J. A. Keene; "Leonard Brightman," Capt. Elijah Powers, and "J. W. Hawkins," Capt. J. W. Hawkins. These smacks are engaged in the menhaden or "moss-bunker" fishery for the oil-rendering and fish-scrap works on Barren Island, and were cruising off Rockaway yesterday in search of schools. About noon a vast school of what the fishermen supposed at first to be menhaden was discovered stretching along the coast for miles. To borrow their language, "The water was red with the fish, but they didn't break the surface as menhaden always do." The boats were lowered, the seines spread, and then it was discovered that the school was of Weak-fish and not menhaden. "I have been in the business for twenty years," said the mate of the Brightman, "and I never saw anything like it before." The fish varied in length from one and a half to three feet, and in weight from three to seven pounds. The "De Blois" took over 200 barrels, the "Hawkins" 150 barrels, and the "Brightman" 350 barrels. The entire catch was estimated at something over 200,000 pounds, which, at the ordinary market price for Weak-fish—seven cents a pound—would amount to $14,000. But, of course, the market price could not be maintained in the presence of such a catch as this, and it was said yesterday afternoon that a strong effort was being made by the wholesale fish-dealers of Fulton Market to prevent the greater part of the fish from being put on sale. The captain of the "Hawkins," which landed at Pier No. 22 East River, foot of Fulton street, obtained a promise from a Fulton Market dealer to take part of his catch, and then made overtures to Mr. Eugene G. Blackford, of E. G. Blackford & Co., Beekman street, to sell the remainder. As soon, however, as the Fulton Market dealer learned of the offer to Mr. Blackford, he refused to take any of the fish. The captain of the "Brightman," however, had better luck. H. M. Rogers & Co., of No. 11 Fulton Market, engaged to take his entire catch of 350 barrels, and immediately put two men in charge of the boat. The "De Blois" meanwhile had made fast against the bulkhead at the foot of Beekman street, and Captain Keene failing to come to terms with the Fulton Market dealers, engaged P. Owens, of No. 104 South street, who manages the peddling trade for the Fulton Market dealers, to dispose of his fish. A crowd speedily gathered about the boat, and the fish sold almost as fast as they could be handled at twenty-five cents a pair. The pressure of the crowd became so great at one time that police assistance was invoked, and Officer William Brown, of the steamboat squad, was detailed to stay on the boat. While Owen was selling the fish at twenty-five cents a pair, an attempt to break the price was made by two well-known "longshore" characters, Jack Sullivan, the shark-catcher, and T. Long, *alias* "Blindy," who bought one thousand pounds of the fish at one cent per pound, and stood on the street retailing them at twenty cents per pair.

Fish-dealers say that there will be no difficulty in selling all the fish this morning at from one to three cents per pound. Friday morning, they say, is the best in the week for the sale of fish. Tons of ice were cracked last evening and put on the fish to keep them fresh until to-day.—*New York Times*, 1881.

dant and largest in the autumnal months, when, in his opinion, they come from the north. It is not satisfactorily ascertained, however, whether these fishes, leaving the northern coast during winter time, migrate southward or move towards the warm waters of the Gulf Stream. They return to the coast of the Middle and Northern States early in the spring, the first being taken in May, and are most abundant from June to September.

They are common in summer in Eastern markets, but do not bring high prices, the flesh being soft and flabby, and of little value except when fresh from the water.

According to the report of the Commission of Inquiry into the Fishes of Narragansett Bay, the Squeteague was ten times as abundant in 1870 as in 1869, and was first noticed there, after a long absence, about 1866. It is said that when they appear off the coast of New Jersey, about the middle of June, they are found to be filled with spawn, but this statement requires confirmation. Thousands of individuals have been examined by the Fish Commission naturalists at different times in the summer, and it is but rare that traces of spawn have been found. The precise period of spawning along the coast and the localities where the eggs are laid, as well as the habits of the fish during that period, are but little known, and are well worthy of careful investigation.

At Beasley's Point, the young fish of the year have in August attained a length of about four inches, and differ from the adults in lacking entirely the characteristic spots, these being replaced by broad, vertical bands, which, together with their more compressed form, render their appearance very unlike that of the adult.

The sport of catching the Squeteague is very great, and is highly enjoyed by our coast fishermen on account of the great number that can be taken in a very short time. They usually move about in schools of greater or less size, swimming near to the surface, and requiring a line but little leaded. They take almost any kind of bait, especially clams, soft crabs, or pieces of fish. They bite with a snap, rarely condescending to nibble, and in consequence of the extreme tenderness of the mouth it requires constant vigilance to fasten them, and great care to haul them successfully out of the water.

During the flood tide they occupy the channel-ways of the bays, and during the ebb they generally settle down in some deep hole, where they remain until the next flood brings them out again.

In the night the Squeteague run up the creeks in the salt meadows, where they are sometimes taken in great numbers by interposing between them and the sea, just before the period of high water. This experiment is not a very satisfactory one, however, on the New Jersey coast, in consequence of the great abundance of crabs that accompany the fish: the smaller fish become entangled in the meshes of the nets, thus inviting the attack of the crabs, which cut the nets to pieces, sometimes ruining them altogether in the course of a single night. When taken, the Squeteague makes a peculiar croaking, audible at a considerable distance; and it is said that this is not unfrequently heard from a boat when passing over a school of them in the water beneath.

In the North, as has been already stated, this species is but little esteemed, but in the South it ranks very high. In the Chesapeake they usually average from one to one and a half pounds in weight, though they sometimes attain the weight of twelve pounds. They make their appearance about the 1st of May and remain until cold weather. They are very abundant, and immense quantities of them are salted for winter use.

The Sea Trout, or Deep-water Trout, of Charleston, described by Holbrook under the name *Otolithus thalassinus*, is without much question identical with the Northern Squeteague, although that author states that it differs from this fish entirely in its habits, since it is only found in the

ocean and deep water, and never approaches the bays and inlets along the coast, while it is a larger animal.

The few specimens which he had seen were taken off Charleston Bar, at about twenty miles from land and in about fifteen or twenty fathoms of water. The very peculiarities which he mentioned are characteristic of the adult Squeteague.

117. THE SPOTTED SQUETEAGUE—CYNOSCION MACULATUM.

Associated with the Squeteague in the waters off the coast of New Jersey and on the eastern shore of Virginia is a species belonging to the same genus, but somewhat different, being characterized by the presence of well-defined dark spots. It becomes more abundant as we proceed southward, until off the coast of North Carolina and Georgia, where it is one of the most abundant food-fishes. Owing to its shape and the presence of well-marked spots on the sides it is usually known on the Southern coast as the "Salmon" or "Spotted Trout," and there are not wanting sportsmen in the Southern States who maintain with dogmatic earnestness the existence of the true Salmon Trout in the waters of their coast. This fish is of course in every respect very unlike a trout, and the name "Spotted Squeteague" has been proposed for it. It is difficult, however, to bring about a change in a name which has been in use for several generations, and it is probable that the name "Sea Trout" will always be used. Genio Scott proposed the name "Spotted Silver-sides," which is not particularly appropriate, and which no one but himself has ever used.

The history of American fishes contains very little respecting the habits of this species, although it is so important an element of food to the inhabitants of the Southern coast. We have, however, been favored by Dr. H. C. Yarrow with notes made at Fort Macon, North Carolina, in which many of the deficiencies in our information are supplied. According to his account, the Spotted Trout is not found in that locality during the winter, or only in small numbers, making its first appearance in February on its way from the south, and attaining its greatest abundance about the middle of April.

Little is known of its rate of growth, although, according to some observers, this increase amounts to about six inches per annum; so that a fish of average size, or eighteen inches, may be considered as three years old. There is no perceptible difference in the sexes as to rate of growth or general appearance, excepting in the fuller belly of the female.

Dr. Yarrow states that they come from the south in the spring and pass through the inlets on the flood tide, the date of their first appearance varying with that of the opening of spring. They remain in the vicinity of the inlets and sounds on the coast of North Carolina until about May, when they gradually proceed northward, extending their journey as far as the shores of Long Island, where a few only are taken, although, perhaps, their number may be considerable. They reappear on the coast of North Carolina in September, and thence proceed south, following the same course as that by which they came, but leaving on the ebb instead of the flood tide. They are found in the winter as far south as Saint Augustine, and possibly below this point, although we have no positive assurance of this fact.

At present they are thought to be more abundant than any other fish on the Carolina coast, with the exception of the mullet, having increased in numbers very largely (at least twofold) within the last ten years, possibly in consequence of the intermission of capture during the war. The average length is about eighteen inches, with a weight of two pounds, although they are not unfrequently found three feet in length and ten pounds' weight. They are often found outside of

the beach in great numbers in January, coming in to the shore when the water is warm, about February, as stated. School follows school at intervals of about four or five days, when they seem to go northward and to be absent from the Southern coast for several months. On their return in September, after a short stay, they gradually leave the coast until they finally disappear for the season. Their return season by season is very regular and definite, being relied upon with much confidence. The successive "runs" do not seem to be classified in any particular way, large and small fish of both sexes coming in together. The colder the weather the less tendency they appear to exhibit to come towards the shore.

At their first appearance in the spring the spawn is not appreciable, nor, according to Dr. Yarrow, do they have any development of the ovaries during their stay on that coast; and he is under the impression that they breed during their autumnal and winter stay farther south. This, however, is scarcely probable, it being more likely that their spawning ground is more to the north, perhaps off the coast of Virginia.

They are said never to take the hook, and to be captured entirely by nets. Their presence is generally made known by the schools of porpoises which follow and feed upon them. Swimming low in the water, they make no ripple on the surface, as is the case with mullets. The time of their capture is usually on the young flood, as in their movements along the shore they come in on the rising tide and depart on the ebb.

Like their representatives in the north, these fishes are fond of penetrating, for a short distance at least, into the mouths of rivers, remaining, however, only about a week; this, according to Dr. Yarrow, is their habit on the coast of North Carolina, before leaving for the North.

They prefer sandy and grassy bottoms, and are particularly fond of shallow water, four or five feet deep, especially in still water and eddies. Their favorite food is small mullet and other diminutive fish, as well as still more largely shrimps and small crustaceans; while, on the other hand, they are eaten voraciously by Weak-fish, bluefish, Drum, porpoises, etc.

As already stated, this fish is seldom if ever taken with the hook, at least for purposes of the market, nets being generally employed, some few being occasionally speared. They are taken in seines, usually having a mesh of about one and one-half inches, made of No. 8 cotton twine, about one hundred yards long and ten feet deep. When the fish first begin to make their appearance the fishermen establish themselves in their boats, just outside the surf, and watch along the crest of the breakers. When the fish are seen the net is paid out from the stern of the boat, one man leaping overboard with a rope attached to one end of the net, while a man in the boat pulls rapidly around the school so as to inclose it. The net is then drawn carefully to the shore. The average catch of two men for a day may be set at about three hundred pounds, although a much greater amount than this could be taken if desirable.

They are used when fresh, and sent up into the small towns in the interior in large numbers. The flesh is of an excellent quality, much superior to that of the Weak-fish, being firm, white, and flaky, and will keep well for three or four days, unless the weather be too warm. It is sometimes salted down for home use by the inhabitants along the coast, and much esteemed. Dr. Yarrow estimates that about two hundred barrels were salted during the season of 1871 by the fishermen in his vicinity. The fish bring about $3 per hundred at wholesale, and $5 at retail, this being equal to the average for the last ten years.

Mr. Silas Stearns has recently prepared the following notes regarding the habits of the Spotted Squeteague as observed by him in the Gulf of Mexico:

"The Spotted Trout is abundant from Key West to Mexico. In the Pensacola region it is present all the year, although most abundant in summer. It prefers to remain in shoal waters

on grassy bottom, where it finds small fish and shrimps in abundance for food. It breeds in inside waters in July or August. Quantities of the fry are seen in August and September. They do not often form in schools in the bays, but in some places are so plentiful that it is not unusual to catch five or eight barrels at one drag of a seine. One man fishing with hook and line sometimes catches one hundred in less than a day. The Trout is an excellent food-fish, and of considerable importance to the fish trade. The demand for it would be much greater if it was not so hard to preserve in this climate."

118. THE SILVER SQUETEAGUE—CYNOSCION NOTHUM.

The Silver Squeteague, *Cynoscion nothum*, called at Charleston the "Bastard Trout," while resembling in shape the two species already described, is easily distinguished from them, being of an uniform silvery hue, the back being slightly darker than the rest of the body.

One or two individuals have been taken in Chesapeake Bay, but it has rarely been observed north of South Carolina, whence Holbrook obtained the specimens from which the original description was made. I have obtained one or two individuals from the mouth of the Saint John's River, where they are not distinguished by the fishermen from the Shad Trout, or Northern Squeteague. In the Gulf of Mexico, according to Stearns, it is common in company with the Spotted Squeteague, and, as far as has been observed, its habits are similar. It is, however, according to Jordan, less abundant, and is not to be found at all seasons. It is most abundant in September and October, but no spawning fish or young have been seen. The "White Trout," as it is called in Pensacola, is is caught with hook and line in company with the Spotted Trout.

119. THE DRUM—POGONIAS CHROMIS.

Next to the sword-fish, tunny, Jew-fish, and halibut, the Drum is perhaps the largest of the food-fishes of our coast. It is most abundant in the Gulf of Mexico and in the Southern Atlantic States, though nearly every summer a few specimens appear on the south coast of New England. In one or two instances individuals have been observed as far north as Provincetown, Massachusetts. In the Gulf it is common everywhere, even to the southern boundary of Texas; how much farther south it goes there is at present no means of determining. Ichthyologists formerly supposed that there were two species, one of which, of small size and conspicuously banded with brown and white, was called the "Banded Drum," *P. fasciatus*, or "Little Drum." This is now well known to be the young of the *P. chromis*. It seems curious that the changes of color in relation to age, although known to Cuvier forty years ago, should have been overlooked by American naturalists, and that the species *P. fasciatus* should have stood as valid until 1873.

My own observations upon the Drum have been made chiefly in Florida. Specimens of ten and fifteen inches are abundant in the Lower Saint John, and are frequently taken at Jacksonville, even as high up the river as Doctor's Lake. Large ones are seldom known to pass the bar at Mayport. The young are very dissimilar to the adult fish, though the fishermen recognize the actual relations. In this respect they are more discriminating than the ichthyologist Holbrook, who described them as distinct species. The adult is known as the "Black Drum," the young as the "Striped Drum." In addition to the marked differences in color, the young has a much more shapely body than the adult, much higher in proportion to its length. The full-grown fish sometimes weigh eighty pounds, though the average is perhaps not more than one-quarter as large. They are sluggish swimmers, and are especially adapted to life on the bottom, where their

long, sensitive barbels aid them in their search for buried treasures of food. They feed upon all bottom-dwelling invertebrates. Their teeth are extremely heavy and pavement-like; their jaws are provided with very powerful muscles, by means of which they can crush with great ease the shells of the most strongly protected invertebrates.

It is claimed by oyster-planters that the Drum is very destructive[1] to the oyster-beds. Mr. Stearns writes: "Oysters are their favorite food on the Gulf coast, and they destroyed a great many at Apalachicola, Saint Andrew's, Mobile, and Galveston Bays. The Mobile oyster-planters attribute the bulk of their losses to Drums. At Pensacola I have known a boat-load of oysters, fifty barrels, that were thrown overboard to be preserved, to be entirely consumed in eight or ten days by them, leaving but a heap of broken shells."

While it is probable that the Drum feeds upon oysters as well as upon crabs or shrimps, it is probable that the extent of their destructiveness has been somewhat exaggerated; for instance, it was claimed a few years ago that oysters in New York Bay to the value of hundreds of thousands of dollars were destroyed by Drums. This seems quite unlikely, since the Drum is by no *means a common fish so far north as New York.*

The name "Drum," as every one knows, alludes to the loud drumming noise which is heard, especially in the breeding season, and is doubtless the signal by which the fish call to their mates. This habit of drumming is shared by many fishes of this family, but appears to be most highly developed in the Drum, and in a European species known as the Maigre, *Sciæna aquila.* M. Dufossé has investigated very thoroughly the physiological causes of these sounds, which appear to depend largely upon the action of the air-bladder.

Mr. S. C. Clarke has made some interesting communications regarding their breeding habits. The male is the larger, and is more brightly colored, particularly at the breeding season. The male drums very loud, the female in a softer tone. Fish under twenty pounds in weight do not breed. About the Halifax Inlet, Southern Florida, they spawn in March in the salt-water rivers. The ova sink to the bottom. They are as large as B-shot, dark brown in color, and are often seen to run from the parent fish when it is captured. In a large fish the roe sometimes weighs six *or seven pounds. In the northern part of the Gulf of Mexico, according to Silas Stearns, they* spawn in April and May in inside waters.

The northern limit of the species appears to be defined by Cape Cod. In 1873 Mr. James H. Blake captured one at Provincetown. Another, of twenty-five pounds' weight, was secured by Vinal Edwards for the Fish Commission from Rogers' Pound, Quissett, Massachusetts, July, 1874; another large individual, of sixty pounds' weight, was taken near Noank, Connecticut, July 10, 1874, the third instance of its capture known to the fishermen of that vicinity.

Schoepf, writing about the year 1786, says that they were at that time very rare about New York, though he had occasionally seen them at the city market, where they met with sale, though their flesh was none of the hardest.

The Drums captured north of Sandy Hook have been, so far as I can learn, large adult fish Professor Baird found the young fish of this species very abundant in August in the small bays along the shores of Beasley's Point, New Jersey, though few were seen in the rivers.

North of Maryland the fish is of little economical importance. In the Chesapeake region, according to Uhler and Lugger,[2] its flesh is much esteemed, and its roe is a great delicacy; considerable numbers are brought to the Baltimore markets in spring and fall.

[1] New York fishermen say that a school of these fish destroyed seven thousand barrels of oysters in Prince's Bay in two days some years ago.—FRED. MATHER, Chicago Field, September 13, 1879, p. 67.

[2] Rep. Com. Fish. Maryland, reference 76, p. 99.

In the Carolinas, according to a statement of a correspondent, the roe is considered very delicious, and it is customary for the residents of the coast to salt and dry them and send them "up country" to their friends as a very acceptable present.

They are sometimes caught in seines in great numbers and retained living in the seines until disposed of. Their flesh is coarse, but tender, and it is thought to compare favorably with any of the salt-water fish of the region. Drum-fishing with hook and line is one of the most exciting exploits of the sportsmen of this region. In the Nassau River large Drum are taken with hook and line in the spring, and are sold at Fernandina.

The young Drum are often taken in seines in the Saint John's River and sold in the Jacksonville market, and are excellent pan-fish, as my own experience testifies. The large fish are often eaten, but are not so much sought after; perhaps the cause of this is that they are liable to be infested by parasitic worms. A Drum of sixty pounds, taken at Wood's Holl, Massachusetts, 1864, was completely riddled by nematode worms, neatly encysted among the layers of muscle. Some of them were two feet long, with heads larger than large buck-shot.

In the Indian River, according to Mr. Clarke, Drum are caught with hooks and crab bait, and with cast-nets. In summer they are caught in the open ocean; in the winter, in the bays and inlets. Four or five a day is considered good fishing luck. Tides do not affect the fishing. Their flesh is not greatly esteemed. They are sometimes salted, but are chiefly used for compost. "In the Gulf of Mexico," says Stearns, "the Drum is often caught in seines and gill-nets, but is very rarely eaten, as the flesh is dry and tasteless. It attains a large size; specimens weighing thirty-five or forty pounds are taken."

The scales of the Drum are extensively used in the manufacture of the sprays of flowers and other articles of fancy work which are sold, especially in Florida, under the name of "fish-scale jewelry." They are large and silvery, and so hard that it is necessary to remove them from the fish with an axe or hatchet.

The Drum is interesting to the fishery economists less on account of any intrinsic value in itself, than because of its destructive influence upon the oyster-beds. Concerning its relation to the oyster-culturist, I cannot do better than to quote the words of Mr. Ernest Ingersoll: "Knowing the carnivorous propensity of the fish, one can easily imagine how an inroad of such a host must affect an oyster-ground. They do not seem to make any trouble, however, north of New York City, and rarely along the south side of Long Island. At Staten Island and Keyport they come in every few years and devastate thousands of dollars' worth of property. Such a memorable visitation happened about 1850, in July. The following summer the planters in Prince's Bay, fearing a repetition of the onslaught, anchored shingles and pieces of waste tin on their beds, scattering them at short intervals, in the hope that their dancing, glittering surfaces might act as 'scare-crows' to frighten the fish away. Whether as an effect of this, or because of a general absence, no more Drums appeared. In New York Bay, off Caven Point, where the old 'Black Tom Reef' is now converted into an island, one planter of Keyport lost his whole summer's work—material and labor—in a single September week, through an attack by Drums. A City Island planter reported to me a loss of $10,000 in one season a few years ago; but the East River is about the northern limit of the Drums, at least as a nuisance to oyster-culture, so far as I can learn. The vexation of it is, too, that the Drum does not seem to eat half of what he destroys; but, on the contrary, a great school of them will go over a bed, wantonly crushing hundreds of oysters and dropping them untasted, but in fragments, on the bottom."[1]

[1] The great schools in which these fish go are illustrated by the following records from contemporary newspapers: On Monday last John Earle and sons caught, at one draught, in Bristol Ferry, 719 Drum-fish, weighing upwards of fifty pounds each. Niles' *Weekly Register*, July, 1833, also says: "Some days ago a haul was made in Great Egg

120. THE FRESH-WATER DRUM—HAPLOIDONOTUS GRUNNIENS.

By DAVID S. JORDAN.

This species is in the Great Lakes always known by the name of Sheepshead. In the Ohio River it is usually called "White Perch" or "Gray Perch," often simply "Perch." In the lakes of Northern Indiana it is called "Crocus," evidently a corruption of "Croaker." In the Southern States the name "Drum" predominates; that of "Thunder-pumper," also used for the bittern, *Botaurus lentiginosus*, is heard along the Mississippi River. Southwestward, in Louisiana, Texas, and Arkansas, it is always known as the "Gaspergou." These names, "Croaker," "Drum," "Thunder-pumper," etc., refer to the croaking or grunting noise made by this species in common with most Sciænoids. This noise is thought to be made in the air-bladder by forcing the air from one compartment to another. Another name used in the southwest is "Jewel-head."

This Drum is very abundant in all large bodies of water throughout the Western States, from the Great Lakes to the Rio Grande. It seldom enters small streams. It feeds largely upon crustaceans and mollusks, but sometimes swallows other fishes. It is rather a bottom fish than otherwise. Its value as a food-fish depends on the water and food, and, unlike most fishes, its quality seems to improve to the southward. Although from its size and abundance it becomes an important market fish, it cannot at best be considered one of high quality. Its flesh is tough and coarse in fiber, and often of a disagreeable shark-like odor, particularly in the Great Lakes, where it is never eaten. The flesh of partly grown specimens is better than that of the adult.

This fish reaches a length of four feet and a weight of forty to sixty pounds. Those usually seen in market are much smaller.

Nothing special is recorded concerning its breeding habits. It is apparently not at all migratory.

This species in the Lakes often contains numerous parasitic worms.

121. THE SPOT, OR LAFAYETTE—LIOSTOMUS XANTHURUS.

The Lafayette, or "Spot," *Liostomus xanthurus*, is found along our coast from New York to the Gulf of Mexico, and is known in New York and elsewhere as the "Spot," on the coast of New Jersey as the "Goody" and sometimes as the "Cape May Goody," in the Chesapeake region also as the "Spot" and the "Roach," at Charleston, South Carolina, as the "Chub," in the Saint John's River, Florida, as the "Masooka"—this name being probably a corruption of a Portuguese name, "Bezuga"—and at Pensacola as the "Spot" and "*Chopa blanca*." The name "Lafayette" was formerly used for this fish in New York, though seldom heard at the present day.

Although they sometimes enter the large fresh waters of the South (such as the Saint John's, which they ascend as far as Jacksonville), Günther is by no means justified in his remarkable statement that this is "a fresh-water fish inhabiting the rivers of North America."

Like the other bottom-feeding members of this family, their food consists chiefly of the smaller mollusks and crustaceans. Little is known about their breeding habits in the North. Mr. S. C. Clarke states that at New Smyrna, Florida, they spawn in the bays and inlets in November and December, while Stearns remarks that they spawn in the lower bays and inlets about Pensacola

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Harbor Bay, near Beasley's Point, Cape May, at which 218 Drum-fish were caught, their entire weight being from 8,000 to 9,000 pounds. This is said to be the largest haul of that description of fish ever made in that bay."

Another still larger, noticed as a great haul of Drum-fish: "On Wednesday, June 5, 1804," says the postmaster of Oyster Ponds, Long Island, "one seine drew on shore at this place at a single haul 12,250 fish, the average weight of which was found to be thirty-three pounds, making in the aggregate 202 tons 250 pounds. This undoubtedly is the greatest haul of this kind ever known in this country. A hundred witnesses are ready to attest the truth of the above statement. They are used for manure." (The fish, I suppose, and not the witnesses.—INGERSOLL.)

late in the fall, while the young of all sizes are very abundant in the spring. Concerning this species Professor Baird writes:

"Of the smaller pan-fish of our coast, in excellence of flavor none is considered superior to that known as the 'Lafayette.' Its precise eastern range is not well ascertained, although it is occasionally taken in great numbers off Long Island and the coast of New Jersey. It is most plentiful off the coast of Virginia. The name of Lafayette was given to it by the New York fishermen in consequence of one of its periodical reappearances in large numbers in that region having been coincident with the arrival of Lafayette in this country in 1834. It had been known before that time, but only in scattering numbers.

"According to Dr. Holbrook, it is not much esteemed for food at Charleston, owing to a want of flavor. In the case of this species, as in many others, it is probable that the colder waters of the North impart a superior flavor and excellence to the flesh. This is well known to be the case with the sheepshead, as well as many other species.

"At Beasley's Point, New Jersey, where I have had an opportunity of studying its habits, it makes its appearance in large numbers in August, the first school being composed of small fish, larger ones following them. A short time later they ascend the creeks in great numbers and are taken there in company with the white perch. Their usual size in New Jersey is about six inches, although occasionally measuring ten inches. They do not make their appearance in the New York markets in any abundance until towards the 1st of September, and remain until the end of October, when they disappear. I did not succeed in finding any very young fish, and am unable to state whether they actually spawn on the New Jersey coast, or whether the supply found there and farther north consists of a 'run' from the more southern waters of fish migrating northward, perhaps to escape the increased heat of the southern coast."

The Spot is abundant at Mayport, Florida, in spring and summer. In the Gulf of Mexico, according to Stearns, it is present in the bays all the year, living in shoal water, feeding upon the bottom upon small invertebrate animals, and taken with hook and line and seine. It is extremely abundant, and is considered a good food-fish.

There is a rare species which has been recorded only from Charleston, South Carolina, and Saint George's Island, Texas, known by naturalists under the name *Stelliferus lanceolatus*. It is found in deep water, and is not sufficiently abundant to have acquired a common name.

122. THE RED FISH, OR BASS OF THE SOUTH—SCIÆNA OCELLATA.

The following biography of the Red Drum, *Sciæna ocellata*, is quoted in full from the text prepared by the writer for the illustrated work on "The Game Fishes of the United States," recently published by Charles Scribner's Sons, of New York:

The Southern Red Fish is among the important species upon the coast of the United States from the Chesapeake to the Mexican boundary. Abundant as it is in the Carolinas, in Florida, and in the Gulf of Mexico, the limits of its range appear to be very sharply defined, there being little tendency on the part of individuals to stray away from their wonted pastures. Although the species is often found in the Chesapeake, I am unable to find any record of its capture north of Cape Charles. Mitchill and DeKay refer to it in their treatise on the fishes of New York, but their descriptions are based upon market specimens, probably brought from more southern localities. Professor Baird did not obtain any specimens when he explored the New Jersey coast in 1854, nor are they to be found in Professor Webster's collections from the Atlantic side of the east shore of Virginia. Its range to the south seems to terminate with equal abruptness. Mr. Silas Stearns gives the result of his observations in 1880: 'From Tampa Bay and northward to the Mississippi River it is one of the most common edible fishes, while west of the Mississippi River it is more

abundant than any other sea-fish, evidently increasing in numbers as the Texas coast is approximated.' On the Texas coast it is taken in greater quantity than all other species combined. West of the mouth of the Rio Grande the species has not been recorded, chiefly, no doubt, for the reason that no explorations have been made along the shores of Mexico. The fish fauna of the Caribbean coast of Panama has, however, been carefully studied, and this fish has not been found. It is, therefore, probable that its range is as abruptly limited at the south, perhaps by the peninsula of Yucatan, as it is in its northward extension. It is a noteworthy fact that *Sciæna* does not wander more; for every other species, I think without exception, which is abundant north of Cape Hatteras, is occasionally met with in Buzzard's and Narragansett Bays, these two great pockets in the coast-line of Southern New England in which are lodged so many of the straying Southern marine animals.

"This fish is very much in need of a characteristic name of its own. Its local names are all preoccupied by other more widely distributed or better-known forms which seem to have substantial claims of priority. In the Chesapeake, and south to below Cape Hatteras, it is called the 'Drum'; but its kinsman, *Pogonias chromis*, is known by the same name throughout its whole range from Provincetown to Texas, and is the possessor of a much larger and more resonant musical organ. Some of the old writers coined names for it like 'Branded Drum,' referring to the brand-like spots upon the tail, and 'Beardless Drum'; but these are valueless for common use, like most other 'book-names.' In the Carolinas, Florida, and the Gulf, we meet with the names 'Bass,' and its variations, 'Spotted Bass,' 'Red Bass,' 'Sea Bass,' 'Reef Bass,' and 'Channel Bass.' Many persons suppose 'Channel Bass' to be a characteristic name, but this is a mistake, for the term is applied properly only to large individuals which are taken in the channels of streams and sounds; wherever this name is used, the smaller fish of the species are called simply 'Bass,' or 'School Bass'; even if the word 'Bass' could be so qualified as to be applicable to the species, there is an insuperable objection to its use for any fish of this family. It is a modification of an old Saxon word, *Bears*, or *Baers;* also found in German under the forms *Bars* and *Barsch*, from which 'Perch' and 'Bass' are both evident developments. This name should evidently be retained for the spiny-formed fishes of the perch tribe. I find in my note-book references to thirty-eight distinct kinds of fish called by the name 'Bass,' with various prefixes, all of which are justly entitled to bear this name.

"'Spot' is another name erroneously applied to this fish, and which is the property of a much smaller species of the same family, otherwise known as 'Lafayette,' or 'Cape May Goody.'

"Finally, we have the 'Red Fish' and 'Red Horse' of Florida and the Gulf States, the 'Poisson Rouge' of the Louisiana Creoles, and 'Pez Colorado' of the Mexicans. Although this name is occasionally applied to a much redder fish, the Norway haddock, or red perch of the north, and to the big labroid *Trochocopus* in California, it is perhaps the most characteristic one and that most suitable for general use, especially if modified into 'Southern Red Fish.' The chief objection is that the fish is not always red; in the young there is not a suggestion of this color, while in the adult it is more a tint, an evanescent, metallic reflection of claret from the scales, which is often absent, and at all events soon disappears after life is gone. The number of spots on the tail is variable; sometimes there is one, sometimes eight or ten, and their arrangement is a matter of chance; occasionally they are absent.

"The Red Fish grows to a length of four or five feet and a weight of forty pounds or more. In April, 1877, those to be seen in the markets of Jacksonville, Florida, ranged from one to four feet. In the markets of Washington and New York strings of small ones are often seen. The average size is perhaps ten pounds.

The food is similar to that of the striped bass, which it seems to resemble in habits. It preys upon small fish and the crustaceans with which Southern waters are filled. They swim in scattered schools at times, probably in the spawning season, and may be heard spring above the surface while feeding. At this time the fish are taken in large gill-nets, which are set around them by the fishermen. This species undoubtedly gathers much food from the bottom, although it cannot be so much of a grubber as many other members of the same family, better provided for this kind of foraging by the tactile organs under the chin, and a set of grinding teeth with which to liberate the shells of muscles and barnacles. An accurate observer describes them as swimming along close to the bottom, with head down and body obliquely upward, wriggling through the water, rooting up the weeds and grass, among which it finds quantities of shrimps and crabs. Their enemies are sharks, porpoises, and saw-fish. The power of uttering sounds is also shared by this fish, but probably not to any very great degree. No one has reported observations upon this point.

The movements and breeding habits of this fish have not been sufficiently studied to warrant the framing of a generalized statement of their character. There is need of a careful investigation of this question at different stations along the coast. I cannot here do better than to quote the observations, as yet unpublished, of two excellent observers, one upon the east, the other upon the west coast of the Florida Peninsula: "In the spring," writes Mr. Stearns, "they are seen in large numbers in the Gulf, swimming in shoal water near the coast. This is usually in March and April, though the weather and the temperature of the water seem to influence the time of their arrival. Arriving at the entrance of a bay, their migratory movement ceases, and for days and weeks they may be seen in shoal water near the inlet swimming lazily about in search of food, or lying quite still in deep holes between shoals, where there is comparatively little current and few enemies can reach them. Some seasons immense numbers of Red Fish gather about the inlets before any are noticed inside or coming in, while in other seasons there is but slight accumulation, the schools working in as fast as they arrive. By the 1st of June the 'run' is over, and the fish are believed to have all come in. When once inside the schools break up into small squads, which proceed to the weedy bottoms of the bayous and to the heads of the bays. About the river mouths, where the water is brackish, and even in fresh water, they are found through the summer. While at sea their color is light, and they are so thin in flesh that they are far from desirable as food. In the bays they become very fat and their colors are much darker. In September spawn is found in them in a half-developed state. In October and November they again form in schools and are observed moving out of the inlets to the sea. They do not leave the coast immediately, but follow the beach for some days. At this time they contain spawn which I should think to be three-fourths developed. Many reliable fishermen here have observed that the Red Fish go to sea with spawn in them."

I have never found the young in the north less than ten inches long, but in Pensacola Bay Jordan and Stearns secured numerous young in the seine in April, the smallest measuring two and a half inches. Jordan supposes that they spawn in water of no great depth.

Mr. S. C. Clarke, however, tells the following story about Bass in the Indian River region: 'They enter the rivers and creeks from the sea. The young fish are here all the time. The adults leave the shore in a body when done spawning. They are first seen off the coast in January and February, and remain in the rivers until late in the spring. The males and females swim together, frequenting localities on shoals and sand-banks, where the water is from one to four feet deep and warm. After spawning they scatter. They begin to breed in August and September in the shallow bays and inlets, at which time both sexes are poor and unfit for food. The

spawn is small, brown, about as large as number five shot, and floats. The young are found abundantly in the creeks and bays.'

The fishermen of the Saint John's River told me that in November, when schooling begins, the fish are full-roed, but that in December the eggs have all been spent.

Little need be said here about their commercial value except that they are taken with gill-nets and spears and by the use of bottom-lines, baited with pieces of fish or shrimps. They are much esteemed for food all through the South, resembling the striped bass or rock-fish in flavor and flesh-texture, though possibly somewhat inferior. They enter largely into local consumption, though a few thousand pounds are sent every year to New York and other cities of the North.

In discussing the rank of this species as a game-fish, I cannot do better than quote the words of Mr. H. S. Williams, regarding his experiences in the Indian River region: "I have seen them swimming in shallow water by the hundreds, sometimes ten and twenty, almost, moving with all the regularity of solid columns of infantry; all apparently of the same size. The Red Fish are in season at all times, but best from the 1st of April until January 1. In size they run up to forty, and even fifty, pounds. They readily take mullet bait, and when securely hooked furnish fine sport, for the Red Fish is emphatically a game-fish. I shall never forget my first experience in this line, a day or two before the full of the moon in November. I concluded to try a new hook just sent me by a distant friend. Just at dusk I went down to the river, and baiting my hook with a half mullet, I walked out on a shelving coquina rock, and swinging the hook around my head a few times sent it out into the river to the full length of the line; then filling and lighting my pipe I took a seat and quietly awaited results. The moon, nearly full, was half an hour or more high, not a cloud obscuring its brightness, and it made a highway of silver across the broad river, now calm and smooth as glass. Scarcely a breath of air stirred the leaves of the huge live-oaks above my head, and everything was so still that I could distinctly hear the fish in shallow water a mile away as the small-fry dashed and jumped in their frantic endeavors to escape from the ravenous jaws of their pursuers; in fact, everything was so still that I remember to have heard the sound of a cow-bell, two miles away, as its low, mellow notes were borne over the broad expanse of water. I had occasionally taken a whiff or two at my pipe and watched the fleecy clouds of smoke float slowly upward and dissolve into space, before *something* sent an electric message to my finger from the other end of the line. It was a faint message, scarcely felt, but distinct enough to tell me what was there. A moment's pause and then it was repeated; this time it was emphatic, for the fish picked up the bait in its mouth as daintily as a neatly-gloved lady would pick up an orange, and then let it fall again. Aha! my boy. You are an old hand at the business, and know by past experience that sometimes even the most tempting morsels are dangerous. A moment more it is picked up again, and yet again, and then it is carried a couple of yards or so before it is dropped; and then back again; then further off. Our fish is playing with the bait as a coquette with hearts. The very moment a novice would think that he was going to take it, 'tis dropped and he is gone again. No, not gone, only swimming around in circles, keeping one eye on the prize and keeping away all such intruders as sharks and cat-fish.

"Now for it. The bait is picked up, seized with a vim, as though he meant business, and away he starts with it. Here the inexperienced would jerk the line and perhaps lose the fish, or at least have the whole formula to go over again. But wait; the successful sportsman must practice patience. Again the bait is dropped, but not for long. In a moment it is seized, and this time there is no feint about it. He darts off, the line is drawn tight, then a sudden jerk and a wild plunge tell that the game is safely hooked. And now commences the struggle for life. Away he goes up the stream for fifty yards or more, straining every nerve to get free; then down,

then back again, while the line is pulled just hard enough to draw him in a little nearer the shore; then up and down, each time a still shorter distance. At each effort I feel his powers give way, and then as he makes a turn we pull his head toward the shore and keep it there. Now is the critical period; now, if at all, the line will part or the hook break. I haul the line in rapidly, hand over hand, keeping it taut, for the least slack or a failure to grasp the line firmly would perhaps lose the game. Swerving to and fro, I draw him rapidly in, and with such force does he come that far up the shelving rocks we land our prize, a thirty-pound Bass, a magnificent fellow, his scales glistening like burnished silver in the moonlight."[1]

123. THE YELLOW-TAIL—BAIRDIELLA CHRYSURA.

The Yellow-tail, known as "Silver Perch" on the coast of New Jersey, is quite an important food-fish in the Southern States. But little has been written regarding it, and its excellent qualities are not yet thoroughly appreciated. In fact, it has been confused with other species by both Holbrook and Günther. This fish has not been observed north of New York, where it was recorded by Mitchill and DeKay, the latter of whom stated that it was not uncommon in the summer season.

Professor Baird found the young very abundant about Beasley's Point in 1854, though the adults were unknown to the fishermen Uhler and Lugger, who, following the mistaken nomenclature of Holbrook, confusing this with a species of *Liostomus*, state that it is common in the Chesapeake and Lower Potomac. It is also abundant about Beaufort, North Carolina, and in the vicinity of Charleston.

According to many observers, Yellow-tails are highly esteemed for food at Saint Simon's Island, New Brunswick, Georgia, and in the Lower Saint John's River. They probably never ascend the river much above Jacksonville, though in 1877 great quantities were taken in the month of April at the mouth of the Arlington River. In 1878 the water was so fresh at this point that none could be taken there, though I saw them at Yellow Bluffs in water not perceptibly brackish to the taste. A large majority of those observed at Mayport on April 7, 1875, were full grown and taken at the point of spawning. Others taken by fishermen at Mayport, April 15, 1878, had the spawn running freely from them. The largest adult did not exceed eight inches in length.

On the Florida coast of the Gulf of Mexico, according to Mr. Stearns, they are very common. They were found by Jordan to be very abundant along the shores of Louisiana and Texas. At Pensacola they are known by the name "Mademoiselle." They are present throughout the year, but most plenty from May until November, and are found in company with the Trout and the Spot on the grassy shoals of the bays where they feed and spawn. The time for spawning is in June and July. They feed chiefly upon small fishes and shrimps. They do not school, but swim singly or in pairs. Their extreme length does not exceed ten or eleven inches, the average being about eight. They are regarded as excellent pan-fish.

124. THE KING-FISH—MENTICIRRUS NEBULOSUS.

The King-fish, also known as the "Hake" on the coast of New Jersey and Delaware, and as the "Tom-cod" on the coast of Connecticut, the "Black Mullet" in the Chesapeake, the "Sea Mink" in North Carolina, and sometimes also in the South as the "Whiting," ranges from Cape Ann south at least as far as the mouth of the Saint John's River, Florida, although in the southern part of its range it is frequently confused with the Whiting. It has been obtained by Jordan and Stearns at Pensacola; it is, however, rare in the Gulf. It is discussed as follows by Professor Baird in an unpublished manuscript:

[1] *The Semi-Tropical, iii, 1877, p. 863.*

"This species, well worthy of the name which has been given it, and the estimation in which it is held by New York epicures, as it is certainly savory when taken fresh from the water, leaves nothing to be desired in the way of a fish dish. It is quite abundant off the Middle States, but is rare much to the eastward. A few specimens are occasionally taken in Buzzard's Bay and Vineyard Sound, and Dr. Storer mentions four as having been captured in Massachusetts Bay. It is almost as capricious in its occurrence in the more northern waters as the Lafayette, sometimes being scarcely met with for several successive summers, and then suddenly reappearing, as if migrating from more southern waters. At Beasley's Point, New Jersey, where I have had most opportunity of studying its habits, it appears quite early in the spring with the Squeteague, and is found a good deal in company with it, like that fish seeming to prefer a slight mixture of fresh water, as shown by its keeping in the mouths of rivers and running farther up during the dry season. It takes bait readily and affords excellent sport to the fishermen, although not caught in anything like the same number in a given time as the Squeteague, thirty or forty at a single tide being considered an excellent catch for one boat.

"Nothing has been recorded in regard to the precise time of their spawning or the places where they lay their eggs. The young were met with at Beasley's Point in immense numbers on the sandy bottom as well as in the surf. The smallest were about an inch long. I have taken the young also in considerable number in Vineyard Sound at a time when the old fish were scarcely known. They occasionally run to a considerable distance up the rivers, as I have caught young fish of this species at Sing Sing, on the Hudson, where the water is scarcely brackish. The King-fish run much in schools, and keep on or near a hard, sandy bottom, preferring the edge of channels and the vicinity of sand bars; and they congregate about oyster-beds, especially when the oysters are being taken up, and may be seen under the boats, fighting for the worms and crustaceans dislodged in the operation. They bite readily at hard or soft clams, or even pieces of fish, and are taken most successfully on the young flood. Like the Squeteague, they will occasionally run up the salt creeks at night, and may be captured in gill-nets as the water recedes. This, however, is not so common a habit with them as it is with its associate.

"The price of this fish varies at different seasons of the year, but it is always well maintained, and it is generally valued at nearly as high a figure as the Spanish mackerel. The European analogue of this species (*Umbrina cirrhosa*) is somewhat similar in general appearance, and its flesh is highly esteemed. This feeds on small fishes, mollusks, and, according to Yarrow, on seaweed, sometimes obtaining a weight of forty pounds. This magnitude I have not seen approximated by our species, although it is possible that it may occasionally reach a large size. Of its distribution southward I can find no satisfactory account."

In 1879 numerous small individuals of this species appeared in the harbor of Provincetown, Massachusetts; they seemed, however, to be out of their proper habitat, and many were chilled by the coldness of the water and cast up on the beach. In 1880 and 1881, the species is said to have been particularly abundant on the coast of New Jersey, and to have afforded much sport to anglers of that vicinity, many of whom had not been familiar with it in previous years.

125. THE WHITINGS—MENTICIRRUS ALBURNUS AND M. LITTORALIS.

The Whiting, one of the favorite food-fishes of the Southern coast, is a species very closely allied in its general character to the King-fish of more northern waters. It is said to occur abundantly from Cape Fear River, North Carolina, to the Rio Grande, in Texas. Uhler and Lugger claim that it inhabits the salt water of the Chesapeake Bay and its estuaries, but it is not probable that it is at all abundant. On the coast of South Carolina, according to Dr. Holbrook, "the Whiting

remains all the year round, and although few are taken in December and January, yet they are sufficient to prove themselves constant residents. Near Charleston in the spring and summer months they are very abundant; they enter the mouths of bays and rivers, and are captured in great numbers. They take the hook readily; their favorite bait is the Drum, and being a strong, lively, and active animal, they afford great sport to the fishermen. They prefer deep and running waters, and seldom approach so near the shore as to be taken in seines. Their ordinary food seems to be various species of a small shell-fish," etc.

Speaking of the "Surf Whiting" of Charleston, Holbrook remarks: "This species makes its appearance on the coast of Carolina in the month of April, and continues with us during the entire summer, though very few are taken in July or August. It is only found in shallow water where the bottom is hard and sandy, often forming, when the tide is out, an extensive beach. Its favorite resort is in the neighborhood of the shore where the surf can roll over it from the ocean and bring with it doubtless the animals on which it feeds. In such localities many are captured with the seine and are sold in the market under the name 'Surf Whiting,' in contradistinction to the other species which is called the 'Deep-water Whiting.' Its food seems to be similar to that of the Deep-water Whiting, judging from the contents of its stomach, and yet it is seldom taken with the hook. Hitherto I have only seen this fish in the immediate neighborhood of Charleston. This fish is very commonly supposed to be the adult male of the common Whiting, approaching the shoal water to deposit its spawn. I believed it, from common report, to be such, until frequent dissections proved to me that there are both males and females among them. The flesh of this species is good, but by no means so finely flavored as that of the Deep-water Whiting."

At Mayport, Florida, the Whiting is abundant, and also at the mouth of the Saint John's. The largest observed by me measured ten inches, and in the first week of April was within two or three weeks of spawning. A few are taken in the Saint John's as high up as Arlington. They are abundant in the Indian River. About New Smyrna, Florida, according to Mr. S. C. Clarke, it is called "Whiting," "King-fish," "Barb," and "Bull-head Whiting." They occur in the winter and spring, though seldom in summer. The largest reached the weight of one and a half pounds. They average three-quarters of a pound, the female being usually the larger. They appear about the last of November, and spend the winter in bays and still rivers. They bite in strong currents, not in slackwater. They prefer deep channels and sandy bottoms. They are found in the deepest water and prefer cold water. Their food consists of crabs, shrimps, and small crustaceans, and they feed at the bottom. Half-grown to full-grown fish contain spawn. They spawn in the sea in May. They are taken with a hook by the use of mullet or clam bait at half-tide. They bite best in a strong current in winter and spring. In the Gulf of Mexico, according to Stearns, they are abundant from Key West to the Rio Grande, and are known as the "Whiting," though at Pensacola the name "Ground Mullet" is in use. He writes:

"There are two varieties, which, if they have no specific differences, have at least different habits. One variety lives exclusively in very shoal water along the sandy beaches, appearing to take pleasure from the action of the surf, and swimming in small schools. The other inhabits deeper waters; is found singly, and is of much darker coloring. The former seldom leaves the sea-water, while the latter are often found in brackish and fresh water. I have found ripe spawn in the surf variety in April, and believe they deposit it on the sea-beach. Large specimens of the dark variety were taken in September, 1879, in the Apalachicola River, where the water is fresh. The Whiting is an excellent food-fish."

The two varieties thus referred to by Stearns have been identified by Jordon as the two species *M. albumus* and *M. littoralis*, the latter being the surf-loving species first mentioned.

The Whiting is a delicious pan-fish, sweet and hard, though soon losing its delicate flavor. In Charleston it is regarded as a special dainty. According to Colonel Lyman, when Charleston was closely blockaded and fishing was a hazardous occupation, the commandant of the garrison, who was a *bon vivant*, gave $100 of Confederate money for a string of Whiting.

Some of the early writers called this fish the "Bermuda Whiting," for what reason it is difficult to understand, for the Whiting of Bermuda at the present day is a fish very unlike that of our Southern coast.

The "Surf Whiting," according to Jordan, is not rare at Charleston, and in the Gulf of Mexico is as common as the other species, but is chiefly found in the surf, and hence is less frequently brought into the markets.

126. THE CROAKER—MICROPOGON UNDULATUS.

The Croaker, *Micropogon undulatus*, ranges from New York at least to the Gulf of Mexico, although rarely seen north of Delaware. It occurs also in some of the West Indian islands and south of Brazil. Its name refers to the peculiar grunting sound which it utters, but in the Chesapeake this name has been corrupted into "Crocus." In Texas it is called "Ronco."

At Beaufort, North Carolina, according to Jordan, it is very abundant, and, next to the mullet and the Spot, is the commonest food-fish of the region. Holbrook states that the Croaker makes its appearance off Charleston in the month of May, but becomes common in shallow water in June and July, and is most abundant and attains its largest size in October and November. It is not much esteemed as food, and is only used as a pan-fish.

It is abundant and highly esteemed at Brunswick, Georgia, and everywhere in Eastern Florida, in company with the Spot, ascending the Saint John's as far as Jacksonville.

Stearns writes: "In the Gulf of Mexico it is very common. Is found everywhere in the bays and bayous throughout the year. Lives mostly in shoal water or grassy bottoms. Feeds upon crustaceous animals. Breeds in the bays in November and December. The young are seen in the spring, having grown to a size of two and three inches in length. Is caught with hook and line and seine. Sells with other pan-fish for a low price. It is an excellent food-fish; average length ten inches. At Sarasota Bay, December 8, 1879, I caught two specimens of spawning Croakers that were each fully eighteen inches long—the largest that I have ever seen."

An allied species is *Larimus fasciatus*, which is called "Chub" in Charleston.

127. THE CORVINAS AND RONCADORS OF THE PACIFIC COAST.

By DAVID S. JORDAN.

THE WHITE SEA BASS—CYNOSCION NOBILE.

This species is everywhere known as the "Sea Bass" ("Sea Trout"), sometimes as "White Sea Bass," to distinguish it from the Black Sea Bass, or Jew-fish. The young, while yet banded, are known as "Sea Trout," and generally considered a distinct species, and both are frequently called "Corvina" and "Caravina."

It reaches a length of four to six feet and a weight of fifty to seventy-five pounds, perhaps more. Those usually seen in market average about fifteen.

It ranges from Cape Mendocino southward to below San Diego, being especially abundant from Santa Barbara to Monterey in spring and summer. It is not often seen in winter. Only adults are taken in spring, and it probably comes to the shore from deeper water for the purpose of spawning. It goes in small schools, and its movements are irregular. Its food consists of crustaceans and fishes. It spawns in June or July. It is one of the most important food-fishes

of the coast. Its flesh is excellent, firm and well flavored, and its great size renders it a very valuable species. In the firmness of its flesh it differs strikingly from most of the other species of the genus.

The Corvina—Cynoscion parvipinne.

This species is usually known as the "Corvina" or "Caravina." It is also occasionally called Bluefish. It reaches a length of about two feet, and a weight of eight pounds. It is found from San Pedro southward to the Gulf of California, rarely straying to the north. In San Diego Bay it is abundant. It feeds on crustacea, and especially on small fishes, as anchovies and sardines, and is very voracious. It spawns in July or August. Its flesh is tender, being very similar to that of the weak-fish (*C. regale*). It softens soon, but when fresh is of a fine, delicate quality, and scarcely surpassed by any fish on the coast. Several other species of this genus occur southward along the Mexican coast, where they are among the most important of the food-fishes.

The Red Roncador—Corvina saturna.

This fish is known where found as the "Red Roncador," less commonly as "Black Roncador" or "Croaker." It reaches a length of sixteen inches and a weight of three or four pounds. It is found from Point Concepcion southward in moderate abundance. It feeds largely on crustaceans and spawns in July. It is a food-fish of good quality.

The Roncador—Roncador Stearnsi.

This species is generally known as the "Roncador" (snorer, from the Spanish *roncar*, to snore), and is always considered as the genuine Roncador, the other Sciænoids being to the fishermen bastards. The name "Croaker" is often applied to it. It makes a very distinct grunting noise, probably with its air-bladder, on being taken from the water. It reaches a length of over two feet, and a weight of six to eight pounds. It is found from Santa Barbara southward, usually in abundance. It feeds on crustacea and spawns in July. It is a food-fish of excellent quality.

The Little Roncador—Genyonemus lineatus.

This species is known about San Francisco as the Little Bass. Southward it is called the Little Roncador. The name "Coguard," said by Dr. Ayers to be given to it in San Francisco, is unknown to us. It reaches a weight of little over a pound, and a length of one foot; it is found from Tomales to San Diego, being most abundant from Santa Barbara to San Francisco. It often comes into the markets in large numbers; it feeds chiefly on crustacea and spawns in July. It is a food-fish of good quality when fresh, but its flesh becomes soft in the market sooner than that of most species. Many are dried by the Chinese.

The Yellow-finned Roncador—Umbrina roncador.

This fish is generally known as the "Yellow-tailed" or "Yellow-finned Roncador." It reaches a length of more than a foot, and a weight of two or three pounds. It is found from Santa Barbara southward, and is generally abundant, especially in summer. It feeds on crustacea and spawns in July. It is a food-fish of good quality. Many are split and salted.

The Bagre—Menticirrus undulatus.

This fish is known as the "Bagre" or "Sucker." It reaches a length of twenty inches, and a weight of four or five pounds. It is found close to shore from Point Concepcion southward to Cerros Island, and is generally abundant. It feeds on crustacea, spawns in July, and is a food-fish

of fair quality. In appearance and in value it approaches closely to the Surf Whiting of the Atlantic, *M. littoralis*.

The Queen-fish—Seriphus politus.

This species is known as "King-fish" or "Queen fish." It reaches a length of eight inches, and a weight of half a pound. It ranges from Tomales Bay southward, and is abundant in summer, when it is found in great numbers in the surf along sandy shores. Enormous numbers of them are sometimes taken in seines, especially at Santa Barbara and Soquel. It is not often brought into the San Francisco market. It feeds on small fishes, crustaceans, etc. It spawns in summer. It is a food-fish of excellent quality, but it is too small to possess much economic value.

O.—SHEEPSHEAD, BASS, BREAM, PERCH, ETC.

THE SHEEPSHEAD FAMILY—SPARIDÆ.

The members of this family are especially characterized by their heavy, rather compressed bodies, and by their large heads, strong jaws and teeth, for cutting or crushing the hard-shelled marine animals upon which they feed. They are usually sedentary in their habits, living close to the bottom and browsing among the rocks and piles. Their colors are usually inconspicuous and their motions sluggish. Representatives of this family are found throughout the world in temperate and tropical waters.

128. THE SHEEPSHEAD—DIPLODUS PROBATOCEPHALUS.

The Sheepshead is one of the choicest fishes of our coast. It derives its name from the resemblance of its profile and teeth to those of a sheep, and also from its browsing habits. Unlike most of those fishes which are widely distributed along our seaboard, it has only this one name by which it is known from Cape Cod to the Mexican border. The negroes of the South, however, frequently drop the "s" out of the middle of the word and call it "Sheephead."

This fish has never been known to pass to the north of the sandy arm of Cape Cod, and its northern range is at present somewhat more limited than it was eighty years ago. In the records of Wareham, Massachusetts, they are referred to as being somewhat abundant in 1803, and in Narragansett Bay there is a tradition that they began to disappear in 1793, when the scuppaug commenced to increase in abundance. In 1871, Mr. E. Taylor, of Newport, testified before Professor Baird that his father caught Sheepshead in abundance forty-five or fifty years previous. In 1870 and 1871 the species was again coming into notice in this region, though not at that time nor since has it appeared abundantly. On the south shore of Long Island it is quite abundant, and in New York Harbor and its various approaches, at times, may be taken in considerable numbers. On the coast of New Jersey it is also abundant, and between Cape May and Montauk Point the species is said to attain its greatest perfection as a food-fish. Lugger states that it frequents the oyster localities of all parts of the Chesapeake Bay, but is now more common among the southeastern counties of Virginia, where it comes in considerable numbers to feed upon the animals which live on the oyster bars. It is found about wrecks of old vessels, on which barnacles and shells abound. About Bedford, North Carolina, it is also abundant, and also along the entire coast of the Atlantic and Gulf States, where it frequently ascends, especially in Florida, high up the fresh-water rivers. In the Gulf, according to Stearns, it is abundant on the coast from Southern Florida to Mexico.

The Sheepshead is a bottom-loving species, quiet in its habits, and little given to wandering. North of Charleston it is absent from the inshore waters during the winter season, but it is probable that its wanderings do not extend very far. Holbrook records that it has been taken in Port Royal Sound as early as January, while in Charleston it makes it appearance in April and continues until November. Dr. Mitchill, whose observations of this species in the vicinity of New York, made sixty years ago, are perhaps as satisfactory as any which have been made, remarked that its term of continuance was from the beginning of June to the middle of September. He had, however, known it to stay later, for one of the most numerous collections of Sheeps-

head he ever saw was on the 4th of October, 1814; he had observed it as late as the 17th of October.

In Florida the Sheepshead is abundant along the shores throughout the entire year, and this is also the case throughout the Gulf of Mexico.

It is curious to see how much at variance were the statements of early observers concerning its habit of entering fresh-water streams. Mitchill states explicitly: "He confines himself strictly to the salt water, never having been seen in the fresh rivers." Holbrook, speaking of the vicinity of Charleston, says: "It enters shallow inlets and mouths of rivers, but never leaves the salt for fresh water." In the Saint John's and other rivers of Florida the Sheepshead becomes almost a fresh-water species, the young especially being constantly taken in seines in company with Bass, Perch, and suckers, far above the limits of perceptibly brackish water. It is not yet possible to infer with any certainty what the temperature limits of this species may be, but it would seem probable that they never willingly encounter water colder than 60°, except perhaps in fall, when they are reluctant to leave their feeding grounds.

The statement just made, however, requires a certain qualification. No one knows whether the Sheepshead of our Northern waters go south in winter or whether they simply become torpid and remain through the season in deep holes near their summer haunts, their presence unsuspected. Perhaps it would be wiser to say that they are not actually engaged in feeding when the temperature is lower than 60°, and that their winter habits are entirely unknown. Where the water is throughout the year warmer than 60° they are constantly active. The Sheepshead feeds almost exclusively upon hard-shelled animals, mollusks and barnacles, and particularly on young oysters as they grow attached to stones and sticks of wood. With its strong cutting and grinding teeth and powerful jaws it can easily rip off thick bunches of shells and grind them to pieces. The ordinary bait for it in the North is the soft-shelled clam, while in the South it is caught frequently by the use of shrimps and crabs.

In discussing the habits of this species I cannot do better than to quote quite fully the observations of several writers on fish and angling, many of whom have taken a special interest in the study of its haunts and movements.

Mitchill wrote in 1814: "This noble fish visits the neighborhood of Long Island annually, emerging from the depths of the ocean. He feeds in the recesses and inlets upon the clams and mussels, which are abundant, and on which he loves to feed. He confines himself strictly to the salt water, never having been seen in the fresh rivers. His term of continuance is only during the warmest season; that is, from the beginning of June to the middle of September. He then disappears to the unknown depths of the Atlantic, and is seen no more until the ensuing summer. The Sheepshead swims in shoals, and is sometimes surrounded in great numbers by the seine; several hundreds have often been taken at a single haul with the long sweeping nets in use near Rayner Town, Babylon, and Fire Island. They even tell of a thousand brought to land at a draught. He also bites at the hook, and several are not unfrequently thus caught in succession. The outfitting of a Sheepshead party is always an occasion of considerable excitement and high expectation, as I have often experienced. Whenever a Sheepshead is brought on board the boat more joy is manifested than by the possession of any other kind of fish. The sportsmen view the exercises so much above common fishing that the capture of the Sheepshead is the most desirable combination of luck and skill; and the feats of hooking and landing him safely in the boat furnish abundant materials for the most pleasing and hyperbolical stories. The Sheepshead is a very stout fish, and the hooks and lines are strong in proportion; yet he frequently breaks them and makes his escape. Sheepshead have been caught with such fishing-tackle fastened to their jaws.

When the line or hook gives way, the accident makes a serious impression on the company. As the possession of the Sheepshead is a grand prize, so his escape is felt as a distressing loss. I know an ancient fisherman who used to record in a book the time, place, and circumstances of every Sheepshead he had caught. This fish is sometimes speared by torchlight in the wide and shallow bays of Queens County and Suffolk." Dr. Mitchill concludes his naive remarks by the mournful words: "It is to be regretted that the Sheepshead too often corrupt for want of ice."

Schoepf, writing of the same region forty years before, states that during the period of the Revolutionary war the Sheepshead was very abundant in the summer months and was a very highly prized species. Some unknown writer contributed to Brown's "American Angler," in 1846, the following memorandum:

"These noble fish have become quite scarce in our harbor. The writer has taken them repeatedly near Governor's Island, opposite the Battery, but this was in days long since gone by. Still, they are still taken, occasionally, at Caving Point and at the Signal Poles, at the Narrows, also at Pelham Bridge and Little Hell Gate."[1]

Scott gives the following advice to the Sheepshead angler: "If a resident of New York, you will find Canarsie on the Old Mill, near East New York, the most convenient place from which to take a sail-boat; a boat is generally at hand at either place. Sail down the channel above the inlet toward Near Rockaway, about a mile below Remson's Hotel; feel by sounding for a mussel-bed (they are numerous for a mile along shore), about two hundred yards from which, when found, cast anchor far enough away so that, when the boat toles round from the tide toward the feeding-ground, the cast required for dropping your anchor will be about fifty feet. The water should be about seven feet deep at low tide, and it rises there from four to six feet. The best time is during the period between high and low tides when the water is slack, and until it runs at the rate of five miles an hour, or one hour after it begins to run; for when the tide runs out it is then considered that Sheepshead seek some still-water ground and wait for a moderate motion of the waters. At the right times of tide the location of the mussel-beds is plainly indicated by a fleet of fifteen to twenty sail-boats or hand-line fishermen. Many of them are farmers, who, residing near the shore of Jamaica Bay, employ the interregnum between hay and grass, uniting their profits, and earning from $3 to $10 a day, by fishing for Sheepshead.

"There are many places along our shores better than Jamaica Bay. The Hand-line Committee makes it pay at Fire Island, and there are many superior feeding places in the South Bay; about the wreck of the 'Black Warrior,' near the Narrows, is celebrated for great numbers of them; in truth, our whole coast south of Long Island is rendered inviting by this delicious fish."

Norris wrote: "In fishing for Sheepshead it is a common practice in Lower Virginia and other waters to drive down stout stakes forming an inclosure; to these different species of mollusks will attach themselves in a few months and entice the Sheepshead; when they have made it a place of resort the fisherman ties his boat to a single stake on either side at a convenient distance and throws his bait towards the pen."

Holbrook wrote, in 1860: "At present the best fishing-grounds for the Sheepshead in South Carolina is the breakwater at Sullivan's Island, or the Foundation Rocks at Fort Sumter, at the entrance to Charleston Harbor.

The Hon. William Elliott, in his "Carolina Sports," gives the following account of the peculiar methods employed in catching Sheepshead in Port Royal Sound, South Carolina:

"They are exceedingly choice in their feeding, taking no other bait but shell-fish. Their favorite food is the young oyster, which, under the form of barnacle, they crush with their strong

[1] American Angler's Guide, fifth edition, p. 198.

teeth. Of course they frequent those shores that abound with fallen trees. On the Florida coast they are taken in great quantities among the mangrove trees, whose roots, growing in the salt water, are covered with barnacles. Formerly they were taken in considerable numbers among our various inlets. Wherever there were steep bluffs, from which large trees had fallen in the water, there they might confidently be sought. But as these lands have been cleared for the culture of sea-island cotton, the trees have disappeared, and with them the fish; and it has been found necessary to renew their feeding-grounds by artificial means. Logs of pine or oak are cut and framed into a sort of hut without a roof. It is floored and built up five or six feet high, then floated to the place desired, and sunk in eight feet of water by casting stones or live-oak timber within. As soon as the barnacles are formed, which will happen in a few weeks, the fish will begin to resort to the ground. It is sometimes requisite to do more before you can succeed in your wishes. The greatest enemies of this fish are the sharks and porpoises, which pursue them incessantly and destroy them, unless they can find secure hiding-places to which to retreat. Two of these pens, near each other, will furnish this protection; and when that course is not adopted, piles driven near each other, quite surrounding the pen, will have the same effect. Your work complete, build a light staging by driving down four upright posts at a distance of fifteen feet from the pen, and then take your station on it, provided with a light, flexible, and strong cane reed, of twenty feet length, with fourteen feet of line attached, a strong hook and a light lead. Instead of dropping your line directly down and poising it occasionally from bottom, I prefer to throw the line out beyond the perpendicular and let the lead lie on the bottom. The Sheepshead is a shy fish, and takes the bait more confidently if it lies on the bottom. When he bites you perceive your rod dipping for the water; give a short, quick jerk, and then play him at your leisure. If the fish is large, and your jerk too violent, the rod will snap at the fulcrum—the grasp of your left hand. It has happened that, at one of these artificial grounds, I have taken sixteen Sheepshead at one fishing. What was unusual was, that they were taken in February, when no one thinks of fishing for these or any other sea-fish within the inlets. I ascertained, from the continued experiments of several years, that they could always be taken at this season, and frequently in January also. The difficulty is to find bait, for neither shrimps nor crabs are then in season. In the case referred to the difficulty was thus removed: The lines were rigged with two hooks; upon one was placed an oyster taken fresh from the shell, on the other an oyster boiled. The scent of the first attracted the fish, but so little tenacity was found in it that, before the fish had taken hold of the hook, the oyster was detached; but when, encouraged by the taste of the first, the fish advanced to the second, that having acquired toughness from boiling, would adhere until the hook was fairly taken into the fish's mouth. They clearly prefer the uncooked to the cooked oyster, but the latter was more to the fisherman's purpose. Their fondness for this food suggested the expedient of breaking up the live oysters in the shell and scattering them in the vicinity of the ground; also that of letting down the broken oysters in a wicker basket. Each plan is found effectual in attracting the fish.

"The bluffs, in their primitive state, in which trees enough are found fallen to give the fish both food and protection against their enemies, are only to be met with now among the Hunting Islands, where the barrenness of the land had secured them against cultivation. On two occasions I have enjoyed excellent sport at such places. On one I took twenty-three to my own rod; on another, twenty-four, and desisted from fatique and satiety. They are never taken in such numbers when fishing from a boat with a drop-line on the rocks. It is very rare that as many as twenty are taken in one boat."[1]

[1] ELLIOTT, WILLIAM: Carolina Sports by Land and Water. New York, 1859, pp. 145–149.

Mr. S. T. Walker writes: "In regard to the consumption of moss, etc., by the Sheepshead, I must say that I can hardly answer intelligently. At high tide, when the flats are overflowed, I have often observed the Sheepshead standing on end, tail up and often out of the water, grubbing at the roots of a coarse, rough grass that grows on the flats. When engaged in this way it is easy to capture from two to six at a single throw of the casting-net. I have often observed a yellowish-green vegetable matter among the broken shell in their intestines, but imagined it was swallowed accidentally with the shell-fish, or was possibly attached to the shells themselves."

In the Saint John's River Sheepshead are abundant as far up as the lakes, and about Jacksonville are always associated with the sailor's choice, *Lagodon rhomboides*. They are never seen of large size; individuals of eight inches and less were taken around the piles and river at Arlington and Mayport. "In the Indian River region," says Mr. Williams, "the season for Sheepshead begins the 1st of May. They range in weight from three to seven pounds. Half-grown specimens, which can be taken along the rocks with cast-net or spear, are good pan-fish. They do not take mullet bait readily, hence are seldom taken with the hook. Hundreds of a larger size may be seen in shallow water on the east side of the river, or in calm water, on barnacles attached to sunken logs, or rocks under water."

Mr. S. C. Clarke, writing from New Smyrna, Florida, states that they occur throughout the year and are most abundant from December to March, having decreased in numbers perhaps one-fourth during the past ten years. They winter in the deep water of the inlets and rivers, are regular in their appearance, take the hook at most times, come and go with the tide, swim low, except in the spawning season, when they come inshore and prefer warm and muddy water with shelly bottom. They feed about rocks and logs on clams, shrimps, barnacles, crabs, and oysters, and are best taken in the latter part of the ebb and young flood, and during the season of plenty, from November to March, twenty-five fish may be considered the average result of a day's fishing with hook and line. They are taken with cast-nets and with hooks, using crabs, clams, mussels, and shrimps for bait. They are highly prized, fresh and salt, though they are mostly consumed in the fresh state.

Mr. Clarke also gives some important information regarding the spawning of this fish. He says: "Before spawning they go in schools, but afterwards they scatter. They spawn at the mouths of rivers and inlets in March and April, the sexes mixing together in schools. The eggs are deposited in shallow water near the shore, and are about the size of mustard seed, and dark. At the spawning season the fish play near the surface and become thin and unfit for food. The young fish are abundant in shallow water among the rocks."

Finally, I append in full the statement of Mr. Stearns, which is especially important since it contains an account of their spawning. He writes:

"The habits of the Sheepshead depend somewhat on the nature of the feeding-grounds in those localities where the fish occurs. At such places as Saint Mark's River, Cedar Keys, Homassassa River, and the Mangrove Islands, farther south, it is present throughout the year, in about the same abundance, whether it will take the hook or not; while at Apalachicola, Saint Andrew's, Pensacola and Mobile Bays, and the Louisiana marshes, its habits are those of a migratory fish, which, in a body, at a certain season, approaches, and, later on, leaves the coast. At the latter-mentioned places it is found to a limited extent during the spring and summer. At these same places large schools of Sheepshead appear on the coast during the months of September, October, and November, finally entering the harbors. This is as important and noticeable a movement as the 'runs' of pompano, Spanish mackerel, or hard-tails in the spring, and it is the only time when large quantities are caught. The fish composing the 'run' are very

thin in form and hardly marketable, but after a few days' rest and refreshment in the bays they become fat and desirable for food. The schools having entered the harbors, become somewhat scattered and go to the feeding-grounds, where they are largely taken with hook and line and seine. Any movement seaward to balance this must be gradual, and takes place, I think, in summer, for it is not noticeable.

"The Sheepshead spawns in April and May, in the bays. On June 18, 1878, and in June, 1879, I caught young Sheepshead, measuring a quarter of an inch, in Pensacola Bay. It lives about wharves, rock-piles, old wrecks, oyster-reefs, and, in South Florida, about the roots of the mangrove tree, feeding upon the barnacles that grow in such places. It is caught with hook and line, in fall and winter, at which seasons it is in its best condition. Its average weight is three or four pounds, and its maximum twenty pounds."

When the Sheepshead first appear on our northern coast it is stated by several writers that they are always thin and unfit for food; it would seem from this as if their spawning season was just ended. No one, however, has made any careful observations upon this point north of Florida.

In the South, Sheepshead are usually small, rarely exceeding two pounds in weight. This is also the case in Florida, although large individuals are occasionally seen. About New York Harbor they sometimes weigh from twelve to fifteen pounds, though the average size is not more than half this weight. All authorities agree that the Sheepshead is one of the very finest food-fishes in our waters, many persons preferring it to the salmon, while others compare it to the English turbot, to which, however, it is doubtless much inferior.

In the North the Sheepshead is almost always boiled, but the smaller fish, more commonly taken in the South, are well suited for frying or broiling.

The Pin-fish—Diplodus Holbrookii.

This fish, which is abundant at Charleston and about Beaufort, North Carolina, was first scientifically described by Dr. Bean from specimens obtained in Charleston market, in March, 1878. Jordan found it abundant everywhere near the shores of Beaufort, North Carolina, in which region it reaches but a small size, and is not used as food. It is confounded by the fishermen with the Sailor's Choice.

129. THE SCUP OR SCUPPAUG—STENOTOMUS VERSICOLOR AND S. GARDENI.

Until very recently only one species of the genus *Stenotomus* was known to occur in our waters. Dr. Bean has recently shown that there are two on the Atlantic coast of the United States, in addition to the unimportant species, *S. caprinus*, recently described from the Gulf of Mexico.

The "Scup" of the North, *Stenotomus versicolor*, is by far the most important, though the Southern species, *S. Gardeni*, has considerable commercial value. The former, which is distinguished by its larger teeth and more abrupt profile, is abundant between Cape Cod and Cape Hatteras, the latter has its metropolis on the Carolina coast, but has been found sparingly as far north as Wood's Holl, Massachusetts.

The Scup, which in many respects resembles the Sheepshead, is often known in New England as the "Scuppaug," this word being an abbreviation of *Mishcuppauog*, the name applied to it by the Narragansett Indians. It is to be regretted that it has been corrupted to form two others, neither of which is euphonious or significant. In New England it is generally called "Scup," while about New York the second syllable of the abbreviated Indian name has been lengthened into "Paugy" or "Porgy." The latter name is particularly objectionable because it belongs to the

English fish, and its proper etymology as a fish name is very different. Another Indian word, "poghaden," a corrupted form of the Abnaki name for the menhaden, or moss-bunker, has been changed to "pogy" and "porgy," thus leading to much confusion. "Scuppaug" is an excellent name for the fish, and its claims for general adoption will be recognized by all who wish to see preserved the name of the aboriginal languages of America.

On the Virginia coast the Southern Scup is known as the "Fair Maid." The name "Porgy" is in use about Charleston, South Carolina, but is usually applied to other members of the same family. Their range is much more limited to the south and extends farther to the north than that of the Sheepshead. Holbrook wrote in 1860: "The Porgy is found along our coasts at all seasons of the year, though most abundant in June and July." He further states that its southern limit on the Atlantic border is Cape Florida, a statement probably not susceptible of proof.

The Northern Scup rarely passes the boundary of Cape Cod; in 1878, however, thirty-seven were taken at the Milk Island weir off Thatcher's Island, Cape Ann, Massachusetts, and they appear to be increasing in abundance.

This species does not appear to be indigenous north of Cape Cod. Storer gives the following account of its introduction: "Mr. James Newcomb, fishmonger in the Boston market, informs me that in the year 1831 or 1832 a smack-load of Scapaugs arrived in Boston Harbor. A portion of them were purchased by subscription among the fishermen in the market and thrown into the harbor. The next season two specimens were caught from our wharves; in the summer of 1835, one individual was taken at Nahant, and was considered a very strange fish, no specimen having been known to have been seen there before; in 1836, still another was captured at Nahant. As no specimen had ever been taken so far north before, and as the few taken would lead to the inference that those which had been transplanted from Buzzard's Bay had not bred in the cold waters of this portion of Massachusetts Bay, we are led to believe that the individuals taken immediately around Boston were of the number originally brought from the South. In the year 1834 or 1835, Capt. William Downes, of Holmes' Hole, carried a smack-load of this species from Vineyard Sound and threw them overboard in Plymouth Harbor." Storer, writing in 1867, says that "within a few years small numbers have appeared north of Cape Cod and are yearly captured at Wellfleet and Sandwich."

Judging from the rare occurrence of the species thus introduced, it can hardly be considered to have become naturalized; the few which have been taken were doubtless summer stragglers. In the Boston Society's museum is a specimen taken at Swampscott, June 29, 1860, by J. Phillips. In the Salem Museum is another taken in Salem Harbor, July 23, 1860, by C. A. Putnam. Scup become abundant on the south side of Cape Cod from the 5th to the 12th of May, which would allow ample time for the appearance of a part of the school off the eastern coast of Massachusetts as early as the dates recorded.

Mr. Hinckley, president of the Philadelphia, Wilmington and Baltimore Railroad, informs us that in the winter of 1833 he found a dead Scuppaug on the Cohasset shore; this was its first occurrence in that locality, and none of the fishermen knew it.

In 1856, Captain Atwood recorded the Scup as very rare at Provincetown.

"Sometimes," says Captain Atwood, "I have seen a dozen of these fish. The Scup were never here at all abundantly; only scattering individuals have been taken from year to year. Since 1842, when the mackerel nets were first set in the outside of the harbor, Scup were first seen, and a few have been seen since."

The history of this species, like that of the bluefish, has been very carefully worked out by

Professor Baird;[1] and from this article and an unpublished essay written in 1877 the remainder of this section is made up. Professor Baird writes:

"It makes its appearance, at least in considerable quantity, on the coast of New England about the middle of May, although the advance-guard of very large fish arrive sometimes as early as the middle of April; and it is most abundant toward the 1st of June, and arrives in successive detachments or 'runs' differing in size, the smallest fish coming last. The first run on the southern coast of New England, as stated, takes place about the beginning of May, and consists of large breeding fish, weighing from two to four pounds, and measuring up to eighteen inches or more in length. The spawn is quite well developed at that time, and is said to be at first red, but gradually to become light yellow as it matures. The particular time and place, however, of laying the eggs is not yet known, although it is probable that this occurs early in June, since the schools are said to break up about the middle of that month, and the fish to scatter. It is thought probable that the spawning takes place in the eel-grass which covers the shoal waters of Narragansett Bay and Vineyard Sound.

"According to the fishermen generally, the Scup on first coming into the shores do not take the hook readily, being apparently too much occupied in the business of reproduction, and two weeks usually elapse before they can be caught in this way. They present themselves in large schools of immense extent, and moving very slowly, at about the rate of three miles an hour. From the testimony presented before the committee of investigation of the Rhode Island legislature, they appear to come from the south and west, as when they enter Narragansett Bay they strike the western shore and move up along its edge. They are said, however, to drift slowly backward and forward with the tide, especially at the entrance of this bay. At this time they are very sluggish, and are said sometimes to appear as if blind, and can frequently be taken with the hand, or a very short scoop-net.

"According to Captain Edwards, of Wood's Holl, in proceeding to their breeding-grounds, on the coast of New England, they are taken at Montauk Point three weeks earlier than at Wood's Holl, and a week earlier at Wood's Holl than at Hyannis, still farther east.

"The Scup feed upon a great variety of marine animals, such as worms, small crustaceans, mollusks, etc., and take the hook very freely during the greater part of their stay; in fact, the smaller ones become veritable nuisances to the fishermen, from the readiness with which they pounce upon the baited hook whenever thrown overboard.

"The flesh of the Scup is very much prized by most persons, as it is firm and flaky, and usually sweet, although occasionally a bitter flavor detracts from its palatability. Since the settlement of the coast by the whites, it has been by far the most important food-fish of Fisher's Island and Vineyard Sounds, Narragansett Bay, and of Buzzard's Bay; and the rapid diminution in number has caused the greatest solicitude.

"Of their abundance on the south coast of New England in former times, almost incredible accounts are given. They swarmed to such a degree that their capture ceased to be a matter of sport. The line when thrown overboard could be immediately withdrawn with the assurance of having a fish on each one of two hooks. Any number of fishermen from boats could take five hundred to one thousand pounds a day without the slightest difficulty, the limits of the catch being simply the ability to find a sale.

"In flavor the flesh of this fish is surpassed by very few others on the coast, although its superabundance caused it to be undervalued. The period of greatest development in number of

[1] Report U. S. Commission Fish and Fisheries, part i, pp. 228-235.

this fish coincided with that of the absence of the bluefish, and since the return of the latter to the coast of New England the Scup has become scarce, although still a very important object of pursuit.

"Immense numbers are caught in the pounds and traps in Rhode Island and Massachusetts, and for several weeks the market is usually glutted, a barrelful being frequently sold for twenty-five to fifty cents, or a small fraction of a cent a pound. It is extremely doubtful whether any part of the more northern coast of North America can furnish, within three miles of the shore, as large a weight of fish in mackerel, herring, and cod as has been furnished by the Scup, sea-bass, and tautog alone in the waters of Rhode Island and Massachusetts. Mr. William Davol, of Rhode Island, with his 'gang,' caught 2,400 barrels of Scup, valued at $1,200, at Seconnet, in May, 1860. Fish were purchased by Messrs. Reynolds, Young & Co., of Fall River, and shipped to Philadelphia.[1]

"The Scup is a fish that grows with rapidity, and at two years is almost of sufficient size to be marketable. Throughout the summer young fish of the spring spawning are to be seen floating around in the eel-grass and over the sandy bottoms, having attained a length of from two and a half to three and a quarter inches by the 1st of October. When these fish reappear the next season, thus completing one year of existence, they measure about six inches, six to eight or nine weighing a pound; and by the 1st of September attain an average length of eight inches, including the tail, and a breadth of three inches. (Twelve individuals, measured on the 31st of August, measured from 7.75 to 9 inches in length, and from 2.75 to 3.25 inches in breadth, not including the dorsal and anal fins.) On the 8th of September twenty-five of this age weighed four and three-quarter pounds, or an average of little over three ounces each. In the third year of existence, or at the age of two years, they have increased considerably, though not so rapidly as was once supposed, measuring, on their reappearance, about ten inches, with an average weight of one-half pound. Six weighed in New Bedford, October 9, averaged but little over five ounces each, while the average of those on the stalls in New York, October 17, was a little over eight ounces. After this they grow more quickly. One hundred and ninety-nine, presumed to be three years' fish, weighed on the 6th of September, averaged one and a half pounds each, and measured about twelve inches in length by four and a half inches in width, some individuals being larger and some smaller. The female fish of the second year not unfrequently contains mature eggs. It is in the fifth year, or after the lapse of four years from birth, that the Scup presents its finest development; specimens believed to be of this age measured fourteen or fifteen inches by five to six inches or more, with a weight of two and a half to three pounds. They, however, still continue to grow, specimens being not unfrequently met with eighteen inches long, and weighing four pounds and even more. The dimensions may belong to fish of six or more years of age; more probably, however, of five years. It is, of course, impossible to do more than give average estimates of the weight and size of fish of the same age, the differences probably depending on the fact whether they were spawned by old or young fish, and the period when the eggs were laid, this extending over a considerable length of time in each locality, although the great majority of fish undoubtedly spawn at nearly the same season.

"Abundant as the Scup has been during the greater part of the present century, there appears to be good evidence to show that prior to the year 1800 there was at least one period, if not more, when it was extremely rare. According to Mr. Southwick (page 11), there is a tradition that they first occurred at Newport about 1793, the sheepshead disappearing about the same time. Mr. Lyman, in an article on the possible exhaustion of the sea fisheries, written in 1871, also

[1] Fall River News, 1860.

quotes some negative evidence of the absence of this fish at Compton, Rhode Island, from 1794 to 1803, the 'sheepshead' (more probably the tautog is meant) being spoken of as common, and the Scup not mentioned.

"Mr. John C. Parker, an octogenarian of Falmouth, Massachusetts, states that the Scup were observed there, according to his father's statement, some time after 1790, and had become quite abundant by 1814. On the other hand, however, in 1621, again quoting from Mr. Lyman, Massasoit entertained his half-famished Puritan visitors with 'fishes like bream, but three times so big, and better meat'; this fact, with the description, being applicable to no other fish than the Scup. The European sea-bream is very similar to the Scup, and would readily be referred to the same species by the unobservant traveler.

"Again, Roger Williams, in his 'Key to the Language of the Indians,' speaking of the Scup, says 'mushcup, the bream.' 'Of this fish there is abundance, which the natives dry in the sun and smoke, and some English begin to salt. Both ways they keep all the year, and it is hoped they may be as well accepted as cod at market, and better if once known.' We find no reference to the occurrence of the fish from this date, 1642, up to 1794.

"The time of the arrival of the Scup on the coast varies with the locality. The young probably spend the winter in our southern waters or out in the Gulf Stream, but in the spring commence their migration either along the coast or from the deep seas toward the waters on the south coast of New England. The latter supposition is the more probable, as no Scup are taken on the southern coast of anything like the size of the breeders that visit New England, making their appearance at once in a huge body, extending, apparently, from Block Island to Martha's Vineyard.

"The western division of this army appears to strike first at Watch Hill, to the west of Point Judith, and to make its way slowly along eastward, the smaller or eastern division moving through Vineyard Sound. According to Captain Luce, the Menemsha pounds take the Scup three days or a week earlier than the pounds at Lombard's Cove, and nearly two weeks earlier than at the guano-works at Wood's Holl. The progress of this fish is at first very slow, scarcely exceeding a few miles a day, and its movements appear to be largely regulated by the flow of the tide, going forward with the flood, and partly retrograding with the ebb. According to Mr. Whalley (page 24), of Narragansett Pier, it occupies about four tides, or two days, in moving from Point Judith to Seconnet Point.

"The precise period of their reaching the coast varies with the season, although their abundance generally occurs from the 5th to the 12th of May. In 1871 the fish appeared much earlier than usual, and were on the shore before traps were down in readiness for their capture. Their occurrence was about the 15th to the 25th of April. Breeding Scup were taken at Hyannis the same year on the 27th of April, at least two weeks earlier than usual. They were taken in the fish-pound at Wood's Holl on the 27th of April, but were most abundant on the 8th of May. In 1872 the season was late, and a few scattering Scup were taken at Wood's Holl from the 10th to the 13th of May, but were most abundant at a later date. On the 17th of May ten barrels were taken, and one hundred and fifty barrels on the 9th of June. Some of those captured in the middle of May were of unusual size, weighing four pounds and over. At Newport they were most abundant on the 15th of May, or two days earlier than at Wood's Holl. Here, too, the number of mature fish was less than usual, but the average size greater. Over one thousand barrels were taken in Luce's pound, at Menemsha Bight. It is mentioned as an unusual occurrence that in the spring of 1872 large fish were caught in purse-nets five or ten miles off the shore of Newport, mostly with spawn, although very poor and thin.

"According to Capt. Thomas Hinckley, after passing Seaconnet Point and entering Buzzard's

Bay, the Scup keep along the northern shore and make almost the entire circuit of the bay before appearing at Quissett Harbor and Wood's Holl, their appearance being always later there than at the head of the bay or about New Bedford. Whether it is the fish alone that belong to Buzzard's Bay that enter it, or whether others pass directly between the Elizabeth Islands and Martha's Vineyard, is not yet satisfactorily ascertained. We know, however, that they reached Waquoit, the first pound on the north side of Vineyard Sound, in 1871, as early as April 25, but that the largest numbers were taken from the 10th to the 13th of May. This gives about a week's difference between this point and Newport.

"On the south of Vineyard Sound the fish are netted at Menemsha Bight, where there are several large and effective pounds, three days or a week earlier than at Lombard's Cove, and nearly two weeks earlier than at the Wood's Holl pound.

"According to Mr. Luce, breeding fish enter the tidal ponds on the north side of Martha's Vineyard (formerly in large numbers), where they spawn, accomplishing this operation by the end of June, the ponds being filled with young in August. As soon as frost comes these fish leave for their winter abode.

"A new point was made in the capture of Scup by the fishermen of Block Island during the spring of 1877. Heretofore Scup have been taken in quantities only in the vicinity of the shores, being captured in immense numbers in traps at Seconnet River and by pounds elsewhere, and sometimes by seines. The capture by hand-lines is the more common, and may be carried on at some distance from the shore; but it has never been taken very far from the land. On the occasion referred to, some fishermen, while engaged in capturing mackerel off Block Island, saw what they supposed to be a school and put their purse-seine around it. To their surprise they found their net to contain Scup exclusively. Of these they took at one haul six hundred barrels of one hundred and eighty pounds each, all of marketable size and bringing a good price in the New York market.

"As a general rule, in their movement along the coast the Scup are not found in water shallower than a few fathoms; and it sometimes happens, in the course of heavy storms, that in consequence of the discoloration of the water near the shore the fish move farther out to sea, and on such occasions measurably escape falling into the traps.

"The Scup is very largely a bottom feeder, and depends very much upon mollusks or shellfish for subsistence. I have been informed by the fishermen that they may frequently be seen feeding upon small bivalves of different species, rooting them out of the sand or mud. The stomachs of about two hundred one and one-half pound Scup were examined at one time in the beginning of September. These almost exclusively contained shells of various genera, with some worms and a few amphipods. Its especial food appears to be small shells, crabs, shrimp, and possibly small fish. The abundance of such food on the south coast of New England must be prodigious to support the swarms that even now are found there. It is in regard to this species that a close time is desirable, so that access to the spawning-grounds and freedom from disturbance may be enjoyed by a sufficient number to maintain the species.

"Like all other small fish, they are devoured by their more rapacious fellows, and very largely by bluefish, notwithstanding a general impression to the contrary. The extent to which this takes place will be considered under the head of the bluefish. Halibut, cod, sharks, and other ground-feeders likewise use them up in great numbers.

"As already remarked, the breeding fish do not appear to feed on their first arrival, being then too much occupied in carrying out the reproductive function. As, however, they can be taken with the hook about the 1st of June, we may infer that this is about the time they begin to feed

for themselves. The younger fish probably feed as soon as they reach the shores. No remains of fish have hitherto been found in the stomachs of Scup, and we may conclude that they are not piscivorous.

"Although the period and the general region where the eggs are deposited has been pretty well ascertained, I regret that nothing is known of the peculiar method by which this is accomplished. I have been informed (page 47) that, on hauling up of anchors of boats that have been lying overnight in two fathoms of water, the rope is frequently found coated with spawn sticking upon it. The eggs are doubtless fertilized as discharged, and probably adhere to the gravel, grass, and other objects at the bottom; but as to the precise period of development, nothing is known.

"INCREASING ABUNDANCE OF SCUP.—According to Captain Ashby, of Noank, the young Scup have been extremely abundant in Buzzard's Bay during the summer of 1877, he himself having turned out 2,500 barrels from a small pound worked by him at the Wepeckets, opposite Naushon. He estimates that at least 25,000 barrels have been thus liberated from the various pounds in Buzzard's Bay. In 1880 immense numbers of young Scuppaug were noticed in Narragansett Bay.

"The Scup, like other shore fish, not unfrequently suffer from changes of weather. Mr. Southwick informed me that he has evidence to show that in the early part of May in 1809, 1818, and 1838, after a cold spell in each of those years, large numbers were thrown on the shore. On the 29th of November, 1871, there was a fall of snow at Wood's Holl, and the next day Scup and sea-bass came ashore in considerable numbers, generally, according to Mr. Edwards, about ten Scup to every yard along the shore for a considerable distance. They were, however, all small fish. While Scup were in greatest abundance, the other fish observed were sea-bass, butter-fish, mullet, etc. Similar facts have been observed in regard to tautog, which indeed seemed to suffer very much more than Scup from this agency.

"As may be inferred from what has already been said, the market at the present time is supplied with Scup from the spring traps and pounds, the capture by these means having become almost entirely exclusive. Formerly, however, they could be taken with the hook from the latter end of May until the end of October, and in any desired abundance. There is no fish on the American coast that bites so freely when abundant, and which can be captured with so much ease.

"I am informed by Mr. Dunham that in the deep holes of the pond at Nantucket, where he has been with his boat, he has sometimes thrown a stone overboard so as to give the Scup a start toward the shore, and then following and throwing his dog overboard, he has driven the fish clear out of the water upon the beach, and has taken as many as five hundred in this way at one time. A similar mode of capture was reported to me as having taken place in the pond at Menemsha Bight.

"The value of the Scup as a marketable fish varies, of course, with the supply; and while they have been sold in early times as low as from ten to twenty-five cents a barrel, and were used as a manure, they are now too scarce for any such purpose. They were worth in 1871 from six to eight cents a pound at Newport, and about two cents at Hyannis. At New Bedford they generally brought ten cents as a maximum price.

"On the coast of Carolina they are said to prefer deep, clear water, with rocky bottom, although they may be taken in almost any locality in the region of their occurrence.

"The Scup remain along the northern coast until about the middle of October, when the larger ones, at least, begin to leave the shores and move out into deeper water. Mr. Vinal Edwards has, however, taken young fish at Wood's Holl as late as the 10th of December, and Capt. John Rogers, of Noank, states that, in fishing for cod on Nantucket Shoals late in Novem-

ber, their stomachs are occasionally filled with small Scup, which drop out of their mouths when hauled on deck, found to be to the extent of five or six at a time. It is quite possible that they, as well as other fish, seek in winter that portion of the Gulf Stream that corresponds in temperature to that of their summer abode; and as the mean summer temperature of the waters of Southern Massachusetts and Rhode Island amounts to about 63° Fahrenheit, they must go nearly to the latitude of Norfolk, Virginia, before they can find that same temperature in the winter season.

The European analogue of our American Scup or Porgy is the *Sparus auratus*, the braize or becker, sometimes bream, of the fishermen. These come on to the European coast in the summer time, and are said to have much the same habits as the American species."

A species closely related to the Scup is the "Goat's-head Porgy" of the Gulf of Mexico, *Stenotomus caprinus*.

Sparus pagrus is rather common at Charleston and Pensacola, and is found also in the south of Europe. There are also in our southern waters various species of the genus *Pagellus*, which resemble in a general way the "Scup."

130. THE SAILOR'S CHOICE—LAGODON RHOMBOIDES.

This species, which bears considerable resemblance in its form to the scuppaug, is found in great abundance from Cape Hatteras south, and around the Gulf coast; also occasionally north of Cape Hatteras; it is known in the lower parts of the Chesapeake Bay, and two or three stragglers have recently been taken at Wood's Holl, Massachusetts. It is not uncommon in the Bermudas. It may readily be recognized by the longitudinal stripes of iridescent color upon the sides, and by the peculiar character of the teeth, each having a prominent notch on either edge.

The "Sailor's Choice," as it is called in the Saint John's River, at Brunswick, Georgia, and about Key West, bears several other names, being known about Cape Hatteras as the "Robin" and "Pin-fish," at Charleston as the "Salt-water Bream," at Brunswick, Georgia, as the "Squirrel-fish" and "Sailor's Choice," in the Saint John's River as the "Sailor's Choice" and "Porgy," in the Indian River region as the "Sailor's Choice," "Scup," and "Yellow-tail," at Cedar Keys as the "Porgy" and "Shiner," and at Pensacola as the "Chopa Spina."

South of Cape Hatteras this fish is exceedingly abundant, and is usually found in company with the sheepshead, which it much resembles in habits. Its jaws, however, are not so strong as those of the sheepshead, by reason of which it is debarred from feeding upon the stronger shelled mollusks and crustaceans, which constitute the principal diet of the latter.

On the Atlantic coast the largest individuals rarely exceed ten inches in length, the ordinary size in Eastern Florida being six or eight inches, with the weight of five or six ounces.

The Sailor's Choice is one of the most deliciously-flavored fishes of our coast, being preferred to the young sheepshead by many of those who are familiar with its good qualities. Lugger states that it enters the drains of the ocean coast of Maryland, and is occasionally caught in the lower part of the Chesapeake Bay. According to Jordan they are excessively abundant everywhere in the harbor of Beaufort, North Carolina, where they are taken by the thousand by boys with hook and line from the wharves, but are seldom used for food, and are found equally numerous through the Gulf States coast.

At Charleston, according to Holbrook, this fish is taken at all seasons of the year, though most plentiful in May and June. No reference is made by this author to its value as an article of food. At Brunswick, Georgia, the Sailor's Choice is highly esteemed; in the Saint John's it is very abundant, and is taken in company with the sheepshead far up the river. It is easily

captured with hooks baited with shrimp, and is considered to be a very superior pan-fish, its flesh resembling that of the scuppaug, though much sweeter and harder.

In the Indian River region, according to Mr. S. C. Clarke, this fish is resident all the year, and is very abundant. The weight of the largest observed by him was one pound. The average weight is about five ounces. They are found in the deep water, or salt water, feeding upon minnows, small crabs, and shrimps. The spawn is pale blue, and of the size of mustard-seed. Young fish are seen in great abundance. They are taken by hook with mullet or clam bait, and also in cast-nets and seines. One hundred are often taken by a fisherman in a day. They are highly prized for food, and are occasionally salted. They are sometimes sent in ice to Savannah and Charleston. "On the Gulf coast," writes Mr. Stearns, "they are very abundant, living and breeding in the bays and bayous. They spawn in winter or early spring, and the young of different sizes may be seen in May and June. The adult fish live in deep water, while the young remain near the shore. Many are caught by hook and line, and with the seine."

131. CERTAIN MINOR SPAROIDS.

The Margate-fish.

This species is known only in the Gulf of Mexico. Stearns writes that it is abundant off the Florida coast, and is found throughout the year in all the gulches, and commonly on the snapper banks in water from ten to thirty fathoms deep. About Pensacola, where it is called the "Porgy," it is seldom eaten, being regarded by the fishermen as a nuisance, for it steals their baits and interferes generally with their fishing. It is, however, used to some extent as bait for red snappers. At Key West it is brought to market in well-boats, and sells readily. The small ones are there called "Porgies" and the large ones "Margate-fish" and "Market-fish."

In West Florida Stearns states that he has often found spawn in them in April. At Cedar Keys, October 28, 1879, he obtained a specimen, seven inches in length, with a gill-net. The largest one he has seen measured fifteen or sixteen inches in length.

The Porgies of the Gulf.

A fish known as the "Sheepshead Porgy" is said by Stearns to be common about the Florida Reefs. It is caught with hook and line, and is sold in the markets of Key West. There are other species, known by the name "Porgy," which are found in this region, such as *Calamus bajonado*, common also at Charleston, where it is called the "White-boned Porgy," *C. megacephalus*, *C. arctifrons*, and *C. macrops*.

The Bermuda Chub—Cyphosus Boscii.

This fish, which is one of the most important of the food species of Bermuda, occurring also in the West Indies and east to Madeira, has but recently been found on our coast. Stearns has observed it in the Gulf of Mexico, where the fishermen call it the "Bream," and individuals have also been taken at Wood's Holl, Massachusetts. It is a most delicious food-fish, and it is hoped that the few which have been seen on our coasts are the precursors of large schools to follow.

Californian Sparoids.

California has two important species belonging to this family, concerning which Professor Jordan has communicated the following information:

"The 'Bluefish,' *Girella nigricans*, inappropriately so called, reaches a length of about fourteen inches, and a weight of three or four pounds. It ranges from Monterey southward, and is very abundant about the Santa Barbara Islands. The young of this species are common inhabitants

of the rock-pools. The 'Bluefish' is entirely herbivorous. It is a food-fish of good quality, but the flesh softens sooner after death than is usually the case with related fishes. It is very tenacious of life.

"The 'Half-moon,' more commonly known by its Spanish name, 'Medialuna,' *Scorpis californiensis*, reaches a length of more than a foot, and a weight of three or four pounds. It ranges from Point Concepcion southward, chiefly about the Santa Barbara Islands, where it is exceedingly abundant, and, in the winter, forms the greater part of the catch at San Pedro. It feeds chiefly upon crustaceans, but is, to some extent, herbivorous. It takes the hook readily, is an excellent food-fish, and, in the Los Angeles market, is second only to the barracuda in importance."

THE SNAPPER FAMILY—PRISTIPOMATIDÆ.

132. THE RED AND GRAY SNAPPERS.

The Red Snapper—Lutjanus blackfordii.

The Red Snapper, although it has been for many years a favorite food-fish of the Gulf of Mexico and Eastern Florida, has but recently become known in Northern markets. About 1874 individuals of this species were occasionally seen in New York and Washington, and shortly after they began to come into notice in the cities of the Mississippi Valley. It was not even described and named until 1877, when Messrs. Goode and Bean, having determined that it was distinct from the West Indian form, which it resembles, described it under the name *Lutjanus Blackfordii*, in honor of Mr. Eugene G. Blackford, of New York City, who has for many years been prominent in all matters relating to fish culture and the fish trade. By reason of its bright crimson color it is the most conspicuous fish ever seen in our markets.

Three years ago the geographical range of this species was supposed to be limited at the north by Savannah Bank, but during the summer of 1880 several specimens were taken along the coast of the Middle States; one, nine and a half pounds in weight, off Port Monmouth, New Jersey, October 5; another, about August 10, near Block Island. This northern extension of its range is quite unexpected, and the fact that even stragglers find their way into our northern waters suggests great possibilities for the future in the way of their artificial propagation and introduction along the coast of the Middle States. In the South it is found associated on the same grounds with the sea-bass, *Serranus atrarius*, which it resembles in habits and manner of feeding. The sea-bass is abundant as far north as Cape Cod, and it is hard to understand why the banks, which are favorite haunts of this fish, should not also be shared by the Red Snapper. In the Gulf of Mexico the Red Snapper is exceedingly abundant in suitable localities from Key West to the Rio Grande.

"About the Florida reefs and as far north as Temple Bay, where there are reefs and rocks, they live in holes and gullies where all kinds of marine animals and fish are most abundant, and sometimes, as I have noticed, off Charlotte Harbor numbers of them will congregate about a solitary ledge protruding over a level bottom of white sand. Throughout this southern district the fishing spots are small, but very numerous; and away from the reefs, where the bottom is chiefly sand, it is only necessary to find rocks or a rocky bottom to find Red Snappers. Since it is impracticable to make use of bearings by which to find the fishing grounds, the fishermen sail about, throwing the lead continually until it indicates the proper bottom. Along the coast from Temple Bay to Texas the bottom declines very gradually to the hundred-fathom curve, forming vast, almost level, plains of sand. In these barren wastes there are gullies of variable size, having rocky bottoms and teeming with animal and vegetable life. These gullies occur at a depth of from twelve to forty-five fathoms, the water in them being several fathoms deeper than the sur-

rounding bottom, and more rocky, and in the deepest parts richer in animal life. Red Snappers are exceedingly abundant in these places, which are the so-called 'snapper banks.' From Temple Bay to Cedar Keys the gullies are numerous in sixteen, eighteen, and twenty fathoms; from Cedar Keys to Saint Mark's, in fifteen and sixteen fathoms. Off Saint Mark's and Dog Island there are a few in five and ten fathoms. From Cape San Blas to the mouths of the Mississippi River occur the best fishing grounds in the Gulf, so far as is now known; gullies in ten and fifteen fathoms of water especially abundant from the cape, fifty miles to the west. West of the Mississippi, on the Texas coast, there are a few which are in twelve and fifteen fathoms. These grounds are found by the use of the sounding-lead, which shows every position by the sudden increase in the depth of the water. Red Snappers live in such places all the year, except, perhaps, in some of the five and ten fathom ones, which are nearly deserted in winter. Off Pensacola there seems to be quite a movement inshore in spring and offshore in fall. In South Florida they are usually associated with the groupers, which occur in the proportion of about three to one, while in West Florida the case is reversed; not more than one fish in ten of those caught is a grouper."[1]

Red Snappers are also known to be abundant on the Savannah Bank and on the Saint John's Bank, off Eastern Georgia and Florida.

The Red Snappers are strictly carnivorous, feeding upon small fish, crabs, and prawns. The temperature of the water in which they live probably rarely falls below 50°. They have no enemies except sharks and two or three enormous spiny-rayed fishes, such as the jew-fish or warsaw (*Guasa*). The only reliable observations upon their breeding habits have been made by Mr. Stearns, who states that they spawn in May and June in the bays and at sea. In June, July, and August they are found in some of the bays of the Northern Gulf, about wrecks and rock-piles, in considerable numbers, and none are taken but the larger adults and the young from one to eight inches long. The spawning season probably extends over a period of several months, Mr. Stearns having found well-developed ovaries in them from April to July. Nothing is known of their rate of growth. They attain the size of forty pounds. In East Florida, however, the average is much less. Mr. Stearns remarks that in the Gulf of Mexico they very seldom exceed thirty pounds' weight, though he has seen several of that size, while the average is eight or nine pounds, and in a large lot may usually be found individuals weighing from two and a half to twenty pounds.

Red Snappers from Florida are frequently quoted in the New York market returns. In 1879 about 12,000 pounds were there sold. They are also shipped to New York, Washington, and Baltimore in winter, the supply in these cities being derived chiefly from Pensacola. Mobile and New Orleans consume considerable quantities, and from these ports they are shipped up the Mississippi River to the principal cities along its line, where the fish is growing to be a staple of much importance. In Saint Louis it is already one of the most highly esteemed food-fishes. The price in New York in 1879 ranged from twenty to twenty-four cents per pound, but they are now less expensive.

The Pensacola Snapper.

The Red Snapper belongs to a genus which is found everywhere in tropical waters; fish resembling it occur everywhere throughout the West Indies. There is a kind of Red Snapper which is abundant on the Bahama Banks and in South Florida. This is *L. campechianus* Poey, perhaps also accompanied by *L. torridus* Cope. Two other brilliant red species occur with *L. Blackfordii* in the Gulf of Mexico—the Pensacola Snapper, *L. Stearnsii*, and the Mangrove Snapper, *Rhomboplites aurorubens*, the former of which might easily be mistaken for the *L. Blackfordii*,

[1] Silas Stearns, MS.

although its color is somewhat less vivid. Concerning this species, Mr. Stearns, whose name it bears, writes: "It is abundant on the Gulf coast, and lives in the bays all the year. In summer it is to be found about stone-heaps, wharves, and old wrecks, where it obtains crustaceous food in abundance. In winter it returns to the deeper places in search of food, and to escape from the cold surface water. During a cold snap in 1876 a great many of these fish were benumbed and floated at the surface, until the sun appeared and warmed them, when they revived and sought the bottom. They spawn in May and June. They are very cunning, and will not readily take the hook. Those commonly seen in the bays are quite small, averaging ten inches in length, while those taken with the Red Snappers at sea are from twenty to twenty-four inches long. It is an excellent food-fish, generally thought to be superior in flavor to the Red Snapper." This fish has as yet been found only on the Gulf coasts of the United States, where it is known as the "Mangrove Snapper." Since this name is used on the Atlantic coast for another species, and has been so used since the time of Catesby, it seems desirable to designate *Lutjanus Stearnsii* by another name, and "Pensacola Snapper" has been suggested.

The Mangrove Snapper—Rhomboplites aurorubens.

The "Mangrove Snapper" of Charleston, called at Pensacola the "Bastard Snapper," is a much more slender and elegantly formed fish than either of the Snappers already described. Its color is less vivid, being somewhat more russet, and is enlivened by the presence of narrow, oblique lines, with gold and yellow upon the sides. It is a swift-swimming fish, probably less given to feeding on the bottom, and more partial to a diet of living fish. It has been found at Jamaica, and as far north as Charleston, South Carolina.

"In the Pensacola region," writes Stearns, "it is a well-known, but not common, species." Single individuals are occasionally brought in from the sea with the Red Snappers and groupers. It is caught at all depths, from ten to thirty-five fathoms, and seldom exceeds eighteen inches in length. As a food-fish it is equal to the Red Snapper. The Bermuda Red Snapper, abundant and much esteemed in those islands, is a small but very brilliantly colored species, not yet described, which is to be called *Lutjanus autolycus*.

The Gray Snapper—Lutjanus caxis.

Another snapper, similar in form to these others, but not red in color, which is called the 'Gray Snapper' at South Florida, and the 'Black Snapper' at Pensacola, *L. caxis*, is abundant about the Bermudas, and has been found on the east coast of Florida, in tropical South America, in Western Africa, and about the Bermudas, where it attains the enormous size of sixty to eighty pounds, and is known as the 'Gray Snapper,' and also, on account of its sly, cunning habits, the 'Sea Lawyer.' Mr. Stearns writes: "It is most abundant in South Florida, living in deep channels, on rocky bottoms, about old wrecks, stone-heaps and wharves; it is considered the most cunning fish on the coast, and is extremely difficult to catch. The young may be seen about the wharves, and the breeding-ground is probably near by. Those usually observed are from ten to twelve inches in length, but I think I have seen specimens which would measure two feet."

133. THE GRUNTS OR PIG-FISHES.

In the inshore waters of the Southern Atlantic and Gulf States occur several species of small fish belonging to the genus *Diabasis*. They are closely related to the snappers, which they resemble in form, and have remote affinities with the perch, the bass, and the porgy and sheepshead. Their colors are usually striking, and they, without exception, are distinguished by the brilliant red color of the inside of the mouth and throat, from which they have sometimes been

called Red Mouths, or Flannel Mouths. From their habit of uttering a loud, rather melodious sound when taken from the water they have acquired the name of "Grunt" and "Pig-fish." In some localities they are also called "Squirrel-fish," in allusion to the same habit. They are, for the most part, bottom feeders, preying chiefly upon crustaceans and small fish. In fact, they are, in most respects, miniature counterparts of the red snapper. In many localities they are in high favor as a food-fish. They have not yet been very carefully studied, but so far as they are now understood the following species are known to occur in sufficient numbers to prove of commercial importance:

The Black Grunt—Diabasis Plumieri.

This species has a brownish body, lighter upon the sides, and has the sides of the head ornamented with numerous horizontal stripes of bright blue, while the posterior half of the lower lip is red. It occurs as far north as Charleston, and Dr. Yarrow claims to have seen it at Beaufort, North Carolina, though there is some question whether this species was not mistaken for another. Holbrook records that it has been observed on the Atlantic borders of South Carolina, Georgia, and Florida. I noticed several small individuals in the markets of Saint Augustine in March, 1877. Stearns mentions the Black Grunt as abundant at Key West among the reefs, and as frequently seen in the markets.

The Red-mouth Grunt—Diabasis aurolineatus.

The Red-mouth Grunt, *Diabasis aurolineatus*, is probably the Flannel-mouthed Porgy, familiar to Florida fishermen, and often taken on the Saint John's Bar. It has also been recently found to be common in Charleston in summer. This species was mentioned in Catesby's great work, published in 1743, under the name of "Margate-fish." When alive its color is bright silvery, but it soon becomes, when taken from the water, of a dull amber-brown, with a slight brazen tint along the back and sides, though the belly remains white. The upper jaw within is white; the palate is salmon-colored; the lower jaw and mouth below are also white in their interior third; the posterior two-thirds, both within and without, are red, and the mouth below; the tongue and fauces are of a similar color.[1] This fish occurs in Northern Brazil and throughout the West Indies, and specimens are recorded from Jamaica, Trinidad, and the Bahamas; it is found in the Bermudas and on our coast at least as far north as Charleston. Stearns writes: "It is quite common on the Gulf coast of Florida from Pensacola to Key West. It is caught with hook and line, and is eaten as a pan-fish. I took an extremely large specimen from the snapper ground between Cedar Keys and Saint Mark's in fifteen fathoms of water. It is not found in the vicinity of Pensacola." Holbrook writes: "The Red-mouthed Grunt is occasionally taken in our waters at all seasons of the year, but is never abundant, as seldom more than a dozen or two are met with in the market at one time. It is not highly esteemed for food, since its flesh lacks both firmness and flavor."

Uhler and Lugger say that it occurs occasionally in the lower part of the Chesapeake Bay, where it is not considered to possess great economical value. The occurrence of this species so far north needs confirmation.

The Pig-fish—Pomodasys fulvomaculatus.

A species belonging to a closely related genus is the Hog-fish, or Grunt, of the Chesapeake, called also "Pig-fish" or "Grunt" in the Gulf of Mexico, *Pomodasys fulvomaculatus*, and known in South Carolina as well as in Bermuda under the name of "Sailor's Choice." Its color is thus

[1] Description by Holbrook.

described by Holbrook: "Body above, pale brown; belly, silvery; sides marked with numerous orange-colored or yellow spots; those above the lateral line disposed in irregular oblique lines, those below it in horizontal rows. Dorsal, anal, and caudal fins with similar spots; sides of the head pale bluish with a silvery tint and marked with yellow spots; lower jaw, orange at the angle of the mouth; internal surface of the gill membrane, bright orange."[1]

Mr. S. C. Clarke has communicated a full account of a species which is either identical or closely related to this. "The common Pig-fish or Grunt of the Indian River region: This fish, answering the same description, occurs at the mouth of Saint Johns River, and is probably the same." Mr. Clarke states that in the Indian River region they spawn in April in deep salt-water rivers, the spawn being very small and of a brown color. The young fish are not abundant, nor are the adults very numerous, though the number has increased of late years. In 1872 and 1873, three or four might be taken in a day, while in 1874 twenty or thirty were taken by one line on a tide. The largest weight is one and a half pounds; the average fish weighs three-quarters of a pound. The Pig-fish come from the sea into the salt-water rivers in December. Their appearance is regular, though they vary in abundance from year to year. They swim low, and prefer to live in deep water with shell bottom. They go out to sea soon after spawning in April; they feed upon small fish, crab, and shrimp. They are captured by hook, with mullet, clam, and shrimp bait; never with nets. They are much prized for food; the best of table fish, rich and delicate.

This species was first described by Mitchill from a specimen taken in the bay of New York. The National Museum has many specimens from various parts of the Southern coast and the Gulf of Mexico. "In New York," wrote DeKay in 1842, "this is a rare fish, but occasionally appearing, as I am informed, in our harbor in considerable numbers. It is a very savory food." Professor Baird did not find it on the coast of New Jersey in 1854. Uhler and Lugger state that it occurs in the salt water of the lower part of the Chesapeake Bay, and is much esteemed for food.

A correspondent, at Hunger's Wharf, Virginia, writes: "In my estimation it is the finest fish that swims. It grows to the size of about one pound, and is now rather scarce. When I was a boy, about forty years ago, they were very plentiful, and I have known three hundred pounds caught at one haul of the seine. They have since gradually become scarcer, and a few years ago we rarely caught one during the season. In 1879 and 1880 they are coming in plenty, especially in 1880, and I believe that in a few years we will have them in plenty again. They come about the 1st of July and remain until November."

At Beaufort, North Carolina, where it is also called "Hog-fish," according to Jordan, it is extremely common everywhere in the harbor. Holbrook wrote about 1860: "The 'Sailor's Choice' makes its appearance in our waters about the month of April and continues with us until November, when the largest are taken. I have found in the stomach of this animal only the remains of smaller fish, and yet it takes the hook readily when baited with shrimps and clams. It is found along the coast from Georgia to Virginia, where it is called "Hog-fish," and is held in great estimation by epicures."

"In the Gulf coast," writes Stearns, "it is common everywhere and throughout the year. It lives in shallow water among the grass, feeding upon small and crustaceous animals. It spawns in April and May and is a choice food-fish. The average length is about ten inches." Stearns also refers to three species known respectively as the "White," "Yellow," and "Black" Grunt, which are found at Key West and upon the neighboring reefs in great abundance. He states that

[1] The colors of the fishes of this group are thus minutely described in order to aid observers in discriminating between the different kinds of these fish which so closely resemble each other. In most cases this has been thought unnecessary, since the plates and the reference to Jordan's "Synopsis" are thought to be sufficient.

"they are taken with hook and line and are brought daily into the market. Before the poisoned water visited that neighborhood the Grunt was the most important as well as the favorite food-fish in the market, but since then they have been scarce, and other fish, to a great extent, have taken their place."

CALIFORNIAN GRUNTS.

On the California coast occur two species of this family; one, known to the fishermen by the name "Sargo," *Pristipoma Davidsoni*, is found from San Pedro southward to Cerros Island, chiefly about the islands, and is nowhere common. It feeds on crustaceans and is a good pan-fish, but is too scarce to have much economic value. It reaches a length of about fifteen inches. Still another, *Xenistius californiensis* Steindachner, *occurs from San Diego to Cape San Lucas. It is too scarce* to be of any importance for food.

THE BLACK BASS FAMILY CENTRARCHIDÆ.

134. THE BIG-MOUTH BLACK BASS—MICROPTERUS SALMOIDES, AND THE SMALL-MOUTH BLACK BASS—M. DOLOMIEI.

Professor Gill's paper, in which he defines the differences between the two species of Black Bass, was published in 1873 in the "Proceedings of the American Association for the Advancement of Science"; but since this volume is not easily accessible, the most important differences are mentioned here. In the Large-mouth the upper jaw extends far behind the eyes, in the other to a point below it. The Large-mouth has from sixty-five to seventy rows between the gill-opening and the base of the tail, instead of seventy-two or more, while on the cheek there are about ten oblique rows instead of seventeen. There are other distinctions, such as the absence in the Large-mouth of scales on the bases of the dorsal and anal fins, the smaller number of rays in the pectoral fins (there being thirteen or fourteen instead of sixteen or seventeen), and the lesser height of the spinous dorsal.[1]

Numerous as have been the zoological names, they are outnumbered by the popular names still in use in different localities. Charlevoix, a Jesuit missionary who explored Canada in 1721, mentions a fish called "Achigan," which is thought to have been the Large-mouth. An earlier allusion to this species, which in the Southern States is still called "Trout," occurs in the writings of René de Laudonnière, who describes the incidents of the first Huguenot expedition to Florida in 1652, under the command of Jean Ribault. The Large-mouth is known in the Great Lake region, especially in Northern New York, as the "Oswego Bass." This name should not be confounded with "Otsego Bass," a local name for the common whitefish. In Kentucky it is called "Jumper"; in Indiana, "Moss Bass"; in the Southern States, generally, "Trout," though on the Tar River of North Carolina it is called "Chub," and on the Neuse "Welshman."

The Small-mouth shares with the Large mouth in the Southern States the names "Jumper," "Perch," and "Trout," and in Alabama, according to Professor Jordan, it is called the "Mountain Trout."

Both species are very widely distributed over the Atlantic slope of the continent east of the Rocky Mountains, and their range is probably much wider than is now supposed, for many of our northern and western waters are unexplored. The Large-mouth and the Small-mouth dwell together in the Great Lakes, and in the upper parts of the Saint Lawrence and Mississippi basins. The Small-mouth is found north to latitude 47° and west to Wisconsin, while southward it ranges to latitude 33°, where Professor Jordan found it in the headwaters of the Chattahoochee and Ocmulgee Rivers, the latter being the only instance of its presence in a stream emptying east of the Alleghanies into which it is not known to have been introduced by man. The Large-mouth ranges farther to the west and north, occurring in the Red River of the North, perhaps as far as Manitoba, in latitude 50°. It abounds in all the rivers of the Southern States, from the James to the Saint John, and in the lower reaches of the streams and bayous connected with the Gulf of Mexico, around to Texas, in latitude 27°.

[1] For fuller information upon this and every other point connected with the species now under discussion the reader is referred to Dr. J. A. Henshall's elaborate and exhaustive illustrated treatise, entitled "Book of the Black Bass," published in 1881 by Robert Clarke & Co., of Cincinnati.

To the waters of New England and the eastern part of the Middle States they are not native. The Small-mouths found their way into the Hudson in 1825 or soon after, through the newly-opened Erie Canal, and they have since been introduced by man into hundreds of eastern lakes and rivers. Many circumstances suggest the idea that in early days, before the various drainage systems were connected by canals, the distribution limits of the two species were much more sharply defined, the Large-mouth inhabiting, perhaps, the upper part of the basin of the Great Lakes and Saint Lawrence and the rivers of the southern seaboard, while the Small-mouth was found chiefly in the northern part of the Mississippi basin. This theory can never be demonstrated, however, for the early ichthyologists had not adopted the accurate methods of study now in use, and their descriptions of the fish they saw are scarcely good enough to guess by. The mingling of the two forms might have been accomplished in an incredibly short time. A few young Bass will multiply so rapidly as to stock a large lake in five years. The Potomac and its tributaries swarmed with them ten years after their first introduction.

Gill states that the two forms of Micropterus were represented in waters of the cismontane slope of the United States, except those of the New England States and the Atlantic seaboard of the Middle States. But one, the Small-mouth, appears to have been an original inhabitant of the hydrographic basin of the Ohio River.

The Bass do not seem to depend closely on temperature. Having no opportunity of avoiding the cold, they sink to the deepest part of their watery domain at the approach of winter, and if the chill penetrates to their retreats their vitality is diminished, their blood flows more slowly, they feel no need of food, and forthwith enter into a state of hybernation. Mr. Fred. Mather kept one in his aquarium nearly all of one winter. It ate nothing, and seldom moved any member except its eyes. In deep lakes, however, they can sink below the reach of surface chills, and here they are sometimes caught with a hook through the ice. In the South their activity never ceases. Any one who has seen Black Bass feeding must have been impressed with their immense power of movement. They soon become masters of the waters in which they are placed. Sunfish, perch, trout, young salmon, and even the ravenous pickerel, are devoured. They feed at the surface on moths, flies, and frogs; they turn over stones in search of crawfish and insect larvæ. Rats and snakes have been seen in their stomachs. A correspondent of "Forest and Stream" relates that once, while fishing in the Chicago River, one of the small frogs used for bait escaped and perched on a portion of an old wreck above the water. A Black Bass came along, and, lifting his head from the water, picked off the frog, and descended to the depths below. The angler finds them at the proper seasons equally eager for fly-hook, trolling-spoon, or still-bait, and always ready for a struggle which puts his rod and line to a severe test. Their leaps are almost as powerful as those of the salmon. The negro fishermen of Florida often surround a body of Large-mouths with a seine, but as the lines are hauled in and the arc grows smaller the dark forms of the "Trout" begin to appear, springing over the cork-line and returning, with a splash and a jet of spray, to liberty. I have seen them rise five or six feet above the water. They are said to be taken best at night, or when the river is high and the water muddy. Otherwise they leap over the seine. Expert seiners coil their nets in such a manner as to prevent the escape of part of the school. The Small-mouths are said, generally, to prefer deep or swift, cool waters, while the Large-mouths live in muddy, black pools, or in the shelter of old stumps and ledges. In Florida they lurk among the lily-pads and aquatic plants in shallow, dark streams, where they feed on a grub called the "bonnet-worm," which burrows in the flower-buds of the "bonnets" or yellow water-lilies (*Nuphar advena*).

The spawning season occurs on the approach of warm weather. Its date does not vary much with latitude. In Florida, in Virginia, and in Wisconsin they build their nests in May and June.

The oldest fish, we are told, sometimes anticipate the ordinary season, while many late spawners are occupied with family cares until the last of July, and some young fish are not ready until October and November.[1] After the spawning is over the Bass are "in season." They take the hook eagerly from July till November. In the winter they are lank and black, though in season till the ice comes.

Concerning their spawning habits, Mr. Hallock, of the Blooming Grove Association, wrote in 1875: "Four years ago one hundred and thirteen Black Bass from Lake Erie were placed in Lake Giles, and their progeny has increased so fast as to insure good sport to the angler at any time. The late spawners are now (early July) in their gravel beds, in the shallow waters along shore, protecting either their spawn or their newly-hatched fry, as the case may be. It is interesting to note the pertinacity with which they guard their precious charges, and the vigor with which they drive away depredators and intruders of all kinds. They will frequently allow a boat to pass over them, scarcely six inches above their backs, and obstinately keep their ground. Sunfish and such are impelled to keep their distance. There are hundreds of these bowl-shaped excavations, eighteen inches or so in diameter, all along the sandy shallow shores of this lake, which is very clear, and in the center some seventy feet deep, fed by bottom springs."[2]

The eggs are much smaller than those of a trout, and, being heavier than the water, rest on the bottom within the limits of the nest. The only estimate of their number with which I am familiar is that made by Mr. E. L. Sturtevant, who found about seventeen thousand in a Large-mouth weighing two and one-half pounds. The rate of growth is easily determined by experience in artificial ponds. In Granby, Connecticut, four-pound fish were taken in 1874, the progeny of two hundred and fifty fish placed in the pond in 1868. The eggs require two or three weeks to hatch. The parents watch them. In September the young are about two inches long; when well fed they grow to four inches the first season. At two years of age they weigh about a pound, few caught in the North weighing more than four pounds. Leaving the egg in June, they grow to two or three inches before cold weather begins—trim, sprightly little darters, with black bands across the bases of their tails. Another twelvemonth finds them in the garb of maturity, eight or nine inches long, and with their organs swelling in preparation for the act of spawning, which they are said to undertake at the age of two years, and when less than a foot long. The ordinary size of the adult fish is two and one-half to three pounds, though they are sometimes taken in the North weighing six or seven pounds. In Florida the Large-mouths grow larger. A seven or eight pounder is not unusual in the Saint John's; and I was told that in March, 1875, a fish weighing nineteen and one-half pounds was caught in the lake at Gainesville, Florida.

Fish-culturists have made many efforts to hatch the eggs of the Black Bass, and have never succeeded. One reason for their failure, perhaps, lies in the fact that while in the shad and salmon the eggs fall from the ovaries into an abdominal cavity, whence they are easily expressed, in the Bass and other spiny-rayed fishes they are retained until the parent fish are ready to deposit them. This failure is the less to be regretted since the young Bass may easily be transported from place to place in barrels of cool water, and, when once introduced, they soon multiply, if protected, to any desired number.

Black Bass are very tenacious of life. The "Germantown Telegraph" mentions some taken at

[1] Mr. Small records the capture of Black Bass containing milt and spawn in November, in the Potomac (Forest and Stream, iii, p. 212). "Sculls," in the same paper, October 30, states that there are in the Schuylkill Bass with unripe spawn; others in July. "R. M. T." speaks of having seen a Bass of half a pound guarding a nest July 10, in the Housatonic (Forest and Stream, iii, p. 292).

[2] Forest and Stream, iv, 357.

10 o'clock a. m., sold and wrapped in paper, left in a warm room till 5 p. m., when they were found to be alive and well.[1]

The first experiment in their transportation seems to have been that mentioned by A. M. Valentine, who states that a pond near Janesville, Wisconsin, was stocked with Black Bass about 1847.[2] In 1850, Mr. S. T. Tisdale carried twenty-seven Large-mouths from Saratoga Lake, New York, to Flax Pond, in Agawam, Massachusetts. The manner in which the Potomac was stocked with Small-mouths is also well known. It was in 1853, soon after the Baltimore and Ohio Railroad was finished, that General W. W. Shriver, of Wheeling, carried a number of young fish from the Ohio to Cumberland, Maryland, in the water-tank of a locomotive engine. These he placed in the basin of the Chesapeake and Ohio Canal, whence they soon penetrated to all parts of the Potomac Basin, and as far down the river as Mount Vernon.[3] The custom of stocking streams soon became popular, and through private enterprise and the labors of State fish commissioners nearly every available body of water in New England and the Middle States has been filled with these fish. This movement has not met with universal approval, for by the ill-advised enthusiasm of some of its advocates a number of trout streams have been destroyed, and complaints are heard that the fisheries of certain rivers have been injured by them. The results have been on the whole very beneficial. The Bass never will become the food of the millions. The New York market receives probably less than ten thousand pounds of them annually, and they are nowhere very numerous. Yet hundreds of bodies of waste water are now stocked with them in sufficient numbers to afford pleasant sport and considerable quantities of excellent food.

135. THE SUN-FISHES AND THEIR ALLIES.

By DAVID S. JORDAN.

THE ROCK BASS—AMBLOPLITES RUPESTRIS Gill.

This species is known by the names of "Rock Bass," "Goggle-eye," and "Red-eye." All these names are in general use; the first most common in the Lake region, the last farther south. It is everywhere abundant in lakes, ponds, and larger streams throughout the Great Lake region and the Mississippi Valley. It prefers clear waters, and is not often found in muddy bayous. It is a hardy and gamy fish, and takes the hook readily. It is a good pan-fish, but not large, its weight seldom exceeding one and a half pounds. Like other "Sun-fishes," it spawns in early summer.

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[1] Forest and Stream, i, p. 410.

[2] Forest and Stream, ii, p. 341.

[3] THE BLACK BASS OF THE POTOMAC.—The Cumberland Daily News claims for Mr. W. W. Shriver, of Wheeling, West Virginia, the credit of originating and executing the plan of transferring the Black Bass, now so abundant in our waters, from the Ohio to the Potomac. The Daily News is no doubt correct. The performance was one to be proud of, and proper credit should be given to the right man. It has been well said that he is a public benefactor who "makes two blades of grass grow where only one grew before." How much more is he a public benefactor who fills a river with food-fishes where there were none before. A letter from Mr. Shriver, written in 1860, is republished in support of the claim for him in this matter, in which he says:

"The enterprise or experiment was contemplated by me long before the completion of the Baltimore and Ohio Railroad to the Ohio River at Wheeling, but no satisfactory mode of transportation presented itself until the completion of that great work (in, I believe, the year 1853), and in the following year I made my first trip, although I made several afterwards in the same year, carrying with me my first lot of fish, in a large tin bucket, perforated, and which I had made to fit the opening in the water tank attached to the locomotive, which was supplied with fresh water at the regular water stations along the line of the road, and thereby succeeded well in keeping the fish (which were young and small, having been selected for the purpose) alive, fresh, and sound."

Mr. Shriver made several other similar excursions, and on each occasion put the young fish into the basin of the Chesapeake and Ohio Canal, at Cumberland, Maryland, where they had free egress and ingress into the Potomac River and its tributaries. The stock originally transferred, some seventeen years ago, has increased prodigiously, and to-day they abound in the Potomac and all its tributaries. They are of good size, frequently being caught to weigh as much as from three to four and a half or five pounds.—*Baltimore Sun*, April 28, 1871.

Rock Bass spawn about the same time as Black Bass. They keep much about sunken logs, roots, etc.

The Mud Bass—Acantharchus pomotis.

This species is found only in the coastwise streams of the lowlands from New Jersey to North Carolina. Its habits are similar to those of the Warmouth, but it is smaller in size, and has little value as a food-fish.

The Sacramento Perch—Archoplites interruptus.

This species is known only by the name of "Perch," a name applied in the San Francisco markets to many very different fishes. It has been thus far found only in the Sacramento and San Joaquin Rivers and tributaries. It is abundant in the lower parts of these rivers, large numbers being shipped to the market in San Francisco. It is there bought and consumed mainly by the Chinese, who value it highly, paying for it more than for any other fish which they consume. Although it is an excellent pan-fish, very similar to the Black Bass, we have never seen any of them bought by Americans. It reaches a weight of little more than one pound. Nothing distinctive is known of its habits.

The Warmouth—Chænobryttus gulosus.

This species is known throughout the South by the name of "Warmouth." The names "Perch," "Sun-fish," "Goggle-eye," and "Red-eye" it shares with others of its relatives. It is found in all the lowland streams from Virginia to Texas, in all the Southern States, and is generally abundant. In habits, food, size, and value it agrees closely with the Rock Bass.

The Black Warmouth—Chænobryttus antistius.

This species, known as "Warmouth," "Big-mouth," "Sun-fish," "Goggle-eye," etc., abounds in the tributaries of the Upper Mississippi, and is often taken in Lake Michigan. In Illinois it is an important food-fish. In size, habits, and value it is sufficiently similar to the Rock Bass.

Common Sun-fish—Lepomis gibbosus.

This is the common "Sun-fish," "Pumpkin-seed," or "Sunny" of the brooks of New York and New England. It is everywhere abundant in the Great Lake region and in the coastwise streams from Maine to Georgia. It is never found in the Mississippi Valley except in its northernmost part, its distribution being precisely like that of the Perch. It reaches, in the Lakes, a weight of about one and a half pounds, and as usually taken is of not over a pound weight. Its flesh is of good quality, similar to that of other Sun-fish of the same size, and is graded as superior to that of the Perch, but inferior to the Black Bass and White Bass. It takes the hook freely, and to the small boy is the perfection of a game-fish. Its breeding habits are thus described by Dr. Kirtland:

"This fish prefers still and clear waters. In the spring of the year the female prepares herself a circular nest by removing all reeds or other dead aquatic plants from a chosen spot of a foot or more in diameter, so as to leave bare the clean gravel or sand; this she excavates to the depth of three or four inches and then deposits her spawn, which she watches with the greatest vigilance; and it is curious to see how carefully she guards this nest against all intruders; in every fish, even those of her own species, she sees only an enemy, and is restless and uneasy until she has driven it away from her nursery. We often find groups of these nests placed near each other along the margin of the pond or river that the fish inhabits, but always in very shallow water; hence they are liable to be left dry in times of great drought. These curious nests are most frequently encir-

cled by aquatic plants, forming a curtain around them, but a large space is invariably left open *for the admission of light.*"[1]

So far as known, the breeding habits of the other species of Sun-fishes agree with those of *Lepomis gibbosus.*

The Long-eared Sun-fish—Lepomis auritus.

This species, like its relatives, receives the general name of "Sun-fish," "Brim" (*Bream*), and "Pearch" (*Perch*). It is found in all the coastwise streams from Maine to Louisiana, but does not penetrate far into the interior. It seldom reaches a weight of much over a pound, but from its abundance becomes in the rivers of the South a food-fish of some importance. Like the others, it feeds on worms, crustacea, and small fishes, and spawns in early summer.

The Blue Sun-fish—Lepomis pallidus.

This fish is known as the "Blue Bream," "Blue Sun-fish," "Copper-nosed Bream," etc., and in Kentucky sometimes as the "*Dollardee.*" *This is the most widely distributed of our Sun-fish,* ranging from New Jersey and the Great Lakes to Florida and Mexico. It reaches a weight of one and one-half to two pounds, and forms an important market fish in some places. Its habits adapt it especially for cultivation in ponds.

Lepomis cyanellus Raf., L. megalotis Raf., L. miniatus Jordan, L. punctatus (Cuv. & Val.) Jor., L. notatus (Ag.) Cope, and L. Holbrookii (C. & V.) McKay.

The small Sun-fishes, and several others of similar size, abound in the fresh waters of the Mississippi Valley, and are known as "Sun-fish," "Bream," and "Perch." *L. cyanellus* and *L. megalotis* are universally abundant both North and South; the others are chiefly Southern. All take the hook readily and are good pan-fish, but from their small size they have no economic importance, and are valued chiefly by urchins and negroes.

Centrarchus macropterus Jor.

We have never heard for this species any name more distinctive than "Sun-fish" or "Perch." It is found throughout the lowland streams of the South, from North Carolina to Florida, Southern Illinois, and Texas, preferring generally rather deep, clear waters. It is rarely seen in upland streams. It is a fish of good quality, but small, rarely weighing more than half a pound. Little distinctive is known of its habits.

The Calico Bass—Pomoxys sparoides.

This species is known by a variety of names, some of the principal of which are the following: In Lake Erie, and in Ohio generally, it is the "Strawberry Bass," or "Grass Bass." The names "Bitter Head" and "Lamplighter" are also ascribed to it by Mr. Klippart, and "Bank Lick Bass" by Dr. Kirtland. In Lake Michigan, the name "Bar-fish" is in general use, giving place in Illinois to the name "Calico Bass." The latter is the most appropriate of these designations, having allusion to the variegated coloration. In the South, like *Ambloplites rupestris*, it becomes a "Goggle-eye" or "Goggle-eyed Perch." The Calico Bass is found in abundance in all the lakes and ponds of the Great Lake region and the Upper Mississippi. It is also diffused throughout the Mississippi Valley, and appears in the streams of the Carolinas and Georgia east of the mountains. Its preference is for quiet, clear waters, with a bottom covered with grass; and in the muddy sloughs and bayous, where the Crappie is abundant, it is rarely seen. *It is an excellent pan-fish,* reaching

sometimes a weight of two pounds, although not usually weighing more than one pound. It is, like its relatives, gamy, but it is not so voracious as most of them. The following notes on its habits and value are from the pen of Professor Kirtland:

"The 'Grass Bass' has not hitherto been deemed worthy of consideration by fish-culturists; yet, from a long and intimate acquaintance with its merits, I hesitate not to pronounce it *the fish for the million.* It is a native of our Western rivers and lakes, where it usually resorts to deep and sluggish waters; yet in several instances, where it has found its way into cold and rapid streams, and even small-sized brooks, by means of the constructing of canals or by the hand of man, it has adapted itself to the change, and in two or three years stocked to overflowing these new locations. As a pan-fish, for the table, it is surpassed by few other fresh-water species. For endurance and rapidity of increase it is unequaled. . . . The Grass Bass is perfectly adapted to stocking ponds. It will thrive without care in very small ponds of sufficient depth. . . . It will in nowise interfere with the cultivation of any number of species, large or small, in the same waters. It will live harmoniously with all others, and while its structure and disposition restrain it from attacking any other but very small fry, its formidable armature of spinous rays in the dorsal and abdominal fins will guard it against attacks of even the voracious pike."[1]

The Crappie—Pomoxys annularis.

This species is commonly called "Crappie" in the valley of the Mississippi. Other names are "Bachelor" in the Ohio Valley, "New Light" and "Campbellite" in Kentucky and Indiana, "Sac-à-lait" and "Chinquapin Perch" in the Lower Mississippi. It is also often confounded with the preceding species, and some of the names of the two are interchangeable. This species is not often seen in the Great Lake region, but throughout the Lower Mississippi and its tributaries it is very abundant. Its young swarm in all the muddy bayous along the rivers, and great numbers of them are destroyed in the fall when these bodies of water dry up. With the exception of its predilection for muddy waters, we know little in its habits distinctive from those of the Calico Bass, and like the latter it is said to be an excellent fish for ponds. Both take the hook, feed *upon small fishes, crustaceans, etc., and both spawn in spring.*

136. THE SEA BASS—SERRANUS ATRARIUS.

The members of the Sea Bass family *Serranidæ,* are similar in form and habits to the Perches, from which they are distinguished by certain anatomical characters, scarcely tangible to persons not experts in ichthyology. The family contains a very large number of species, some of which are to be found in every part of the tropical and temperate seas. On our Atlantic coast there are some twenty species, while in California there are four at least which are of economic importance. Certain European members of this family are hermaphrodite, but there is as yet no evidence that any American species is thus peculiar.

The Sea Bass, *Serranus atrarius,* known south of Cape Hatteras as the "Blackfish," is the most important species on our coast. In the Middle States the Sea Bass is called "Black Will," "Black Harry," and "Hannahills"; about Newport and New Bedford, "Bluefish," and at New Bedford also "Rock Bass." Curiously enough, the Southern name, "Blackfish," is also in use at Oak Bluff, Martha's Vineyard, and, it is said, also in New Jersey. In Gill's "Catalogue of the Fishes of the East Coast" it is stated that the name "Black Bass" is also used for the fish, but this usage has not yet fallen under my observation.

Storer, in his "Fishes of Massachusetts," makes the statement that it is known as the "Black

[1] American Sportsman, February 28, 1874, quoted by Klippart, Report Ohio Fish Comm. for 1875–'76, p. 78.

Bass" and "Black Fish." If this was true at the time of Storer's writing, the usage has since then undergone a very considerable change. The species should be carefully distinguished from the Black-fish of Long Island Sound, which is the tautog, a member of a very different family.

It is claimed by some writers that the Black-fish of the South is distinct from the Sea Bass of the North. This seems improbable, but is worthy of investigation. The chief advocate of this idea was Holbrook, in whose "Ichthyology of South Carolina" may be found a statement of the supposed differences.[1]

The geographical range of the Sea Bass, as at present understood, is as follows: It is at home in all the waters between the Vineyard Sound and the eastern part of the Gulf of Mexico. Stearns writes that it is rather abundant at a few places on the Gulf coast of Florida, where there are rocks and rocky bottoms. In Pensacola Bay they are seen round the piles of stone ballast that lie in shoal water, and also at sea on the fishing grounds near the entrance. They occur in some places in Saint Andrew's, Saint Joseph's, and Apalachicola Bay. South of these places there is more or less rocky bottom, showing either in reefs or in channel-beds, on which Sea Bass are found in abundance. In the vicinity of Saint Mark's, Cedar Keys, and Saint Martin's Reef are some of the best localities. "It is rarely or never," says Jordan, "seen on the sandy coast of Texas." This species has already been recently discovered north of Cape Cod. Previous to 1878 there were on record only four instances of its occurrence east of Monomoy, but in the summer of 1878 several were taken in the Milk Island weir, off Gloucester. There is reason to believe that fifty years ago the Sea Bass was much less abundant in Southern New England than it is now. In Linsley's catalogue of the fishes of Connecticut, published in 1842, the species is described as a great novelty. It is curious, however, that some time between 1830 and 1840 there were, according to Storer, fifty or sixty vessels fishing for Sea Bass in the Vineyard Sound.

In 1787, if Schoepf is to be believed, they were rarely seen in the New York market. A diligent search through the works of the early writers on the fisheries of New England fails to bring to light any allusion to them. It would be interesting to know whether there has actually been an increase in their abundance, or whether this increase has been, as it seems to have been in the case of the Spanish mackerel, due to the introduction of new modes of fishing or the discovery of new fishing grounds. Sea Bass live among the rocky ledges and "spots of ground" which abound along the entire outer coast from Cape Cod to Cape Florida, and in the North it is also found in the large bays and sounds, like Long Island Sound. In the North the best bass grounds are in seven to twelve fathoms of water; off Charleston they are at a depth of twenty to forty fathoms, though throughout this whole region the fish are found also close to shore, and at all intermediate depths where suitable feeding grounds occur. In the Gulf of Mexico, on the other hand, they are found, for the most part, in shoal water; indeed all along the Southern coast the young fish are found close in to the shore, and I have seen a great many taken with hook and line from the sea-wall at Saint Augustine. The temperature of the water affected by this species and by the red snapper corresponds very closely, and in most instances is probably not less than 50°, though in the case of the banks of Connecticut and New York it may be slightly lower.

The Sea Bass is a bottom-feeding and a bottom-loving fish, and rarely comes to the surface.[2] Whether or not those occurring in northern waters migrate southward in winter, or merely go into deeper water, is not yet ascertained. According to Captain Edwards and Captain Spindle, they

[1] HOLBROOK: Ichthyology of South Carolina, page 49.

[2] An exception to this has been recorded by Mr. Charles Hallock, who writes: "Although the Sea Bass is a bottom fish, yet once on an outward-bound voyage to the southward of the Gulf Stream we made fast to a ship's lower mast, found drifting on the surface, which was covered with clams and barnacles and surrounded with Sea Bass. We caught all that we wanted and cut loose. They weighed from five to twelve pounds each, and were all male fish."

make their appearance in the Vineyard Sound from the 1st to the 20th of May up to the 10th of June. Captain Spindle states that no stragglers are ever seen in April. Captain Edwards declares, on the other hand, that they are found in that region in the winter. A careful study of their habits would form an important contribution to zoology.

Bass are somewhat sluggish in their habits The temperature of the body is low, being very nearly that of the surrounding water and the digestion is slow. Although very voracious at times, they seem very much less fat than bluefish of the same size, and their growth is less rapid. They seldom leave the bottom, and there is as yet no evidence that cold weather drives them far from their summer haunts. They retreat, in all probability, into water of greater depth, where they pass the winter in a somewhat torpid state. Like the tautog, they appear to have a habit of lying under loose stones and in cavities among the rocks. I have observed this habit in the tanks of the New York Aquarium. The food of this species, as of its associates upon the same grounds, consists of crabs, shrimps, squids, and small fish. It is stated that the intestines of mackerel and the stomach of menhaden are considered the best bait about Wood's Holl, Massachusetts, while farther south shrimps and pieces of the flesh of fishes, such as small sharks, are frequently used. They are voracious feeders and easily taken on the hook, and their mouths are tough and leathery, so that when once taken they are not easily lost.

Scott states that their feeding time is during the lull of the waters between the turn of the tides, when they are easily taken by the angler. In the North the Sea Bass occupies its feeding grounds in company with the scuppaug or porgy, the flounder, and the tautog, while in the South its associates are the red snapper and the various species of grunt, and on the inshore grounds, among the rocks, it occurs in company with the sheepshead and the king-fish.

The breeding-time is believed to occur in July and August. Mr. Dyer, of Naushon, states that the Sea Bass, when they come into the pounds in the spring, are full of spawn, ready to shoot. Young fish, one or two inches long, are abundant among the eel-grass along the shores of Southern New England. "In the Gulf of Mexico," according to Stearns, "they spawn in early summer, and the young are caught in July and August."

The average size of the fish in New England is about one and one-half pounds. A Sea Bass nine inches long weighs about five ounces; ten inches long, seven to ten ounces; eleven inches long, nine to twelve ounces; twelve inches long, ten to sixteen ounces; while the length of a three-pound fish varies from eighteen to twenty inches. They occasionally attain the weight of four or five pounds, but this is unusual. In the South they are, as a rule, much smaller than in the North. This is especially the case in the Gulf of Mexico. In these waters, and along the southern part of the South Atlantic coast, they rarely exceed a pound in weight. Large male fish are remarkable on account of the presence of a large hump upon the top of the head. This is particularly prominent during the breeding season, and at this time the colors of the whole body are much brighter. The colored plate of this species, drawn by Mr. Kilburn for Scribner's "Game Fishes of the United States," represents a large male at the breeding season, the only picture of this kind that has ever yet been made.

The Sea Bass is of interest to fish-culturists as being the first marine fish upon which the experiment of artificial propagation was tried in this country. This was in June, 1874, when Mr. Mather fertilized a number of eggs at the station of the United States Fish Commission, at Noank, Connecticut. These eggs were placed in shad boxes and were watched for several days as they passed through the early stages of segmentation. A storm interfered with the completion of the experiment.

The Sea Bass is considered one of our most available food-fishes, being especially excellent

for use in chowders; in this respect a rival of the haddock, its flesh being very sweet, flaky, and firm. By reason of the hardness of its flesh it is especially adapted to packing and shipment in ice, and in summer is probably one of the most desirable fishes to be obtained in the city markets. The principal commercial fisheries are located in the Vineyard and Fisher's Island Sound and the vicinity, carried on by Noank and New London smacks off the mouth of the Delaware Bay, and off Charleston, South Carolina. As has already been stated, its distribution is very wide all along the coast, and it is probable that its importance as a food-fish will increase in years to come.

There is a small species (*Serranus trifurcus*) resembling the Sea Bass which has been found only in the vicinity of Charleston, South Carolina, and Pensacola, Florida, where it is called the "Rock Black-fish"; it occasionally finds its way to the Charleston markets.

The Squirrel-fish—Serranus fascicularis.

The Squirrel-fish is usually to be seen in the markets of Charleston, north of which it has never been discovered. The following paragraph from Holbrook's "Ichthyology of South Carolina" contains all that has been observed regarding its habits:

"Little can be said of the habits of this fish. It however appears in our waters in May and June and remains until November. It is occasionally taken with the hook on the black-fish grounds, but is never abundant. Southward it ranges at least to Brazil."

137. THE GROUPERS.

The Red Grouper—Epinephelus morio.

Next in importance to the Sea Bass are the various species of Grouper, members of the genus *Epinephelus*. The "Red Grouper," as it is called in Florida, and in New York markets *Epinephelus morio*, is a large species, sometimes attaining the weight of forty or fifty pounds. There is no certain record of its having been captured north of Florida, where it is called the "Brown Snapper," or "Red-bellied Snapper." DeKay, writing in 1842, stated that it was not unusual in the New York market in June and July, where it was called by the fishermen 'Groper,' or 'Red Groper'; that it is a Southern species and is brought from the reefs of Florida, but that he had been informed by Indian fishermen that it is occasionally, but very rarely, taken off the coast of New York; he added that Dr. Holbrook informed him that it was brought into the Charleston markets from Florida in the months of January, February, and March.

Holbrook wrote: "The Grouper is so seldom seen on our coast that nothing can at this time be said of its habits; but in confinement, as it is brought to us from Key West, it appears very voracious and bold, taking food even from the hand when offered, and always injuring such other species of fish as may be its fellow-captives."

It is very abundant in the Gulf of Mexico and about the Florida Keys, and is said also to be abundant *along the whole coast of East Florida, and is often taken on the Saint John's bar.* Mr. S. C. Clarke writes that it occurs in the vicinity of New Smyrna, Florida, where it spawns in bays and inlets in the months of May and June, as does also the Black Grouper. The only reliable study of its habits which has been made we owe to Mr. Silas Stearns, whose biographical sketch of this species may here be quoted in full:

"The Red Grouper is extremely abundant in the Gulf of Mexico in company with the red snapper. It is most abundant on the South Florida coast, and is found throughout the year on the 'grounds' at sea and in summer in some of the bays. It probably spawns in both places, and in June and July. The young are often caught in Pensacola Bay. In June, 1880, I obtained a young

one about one inch in length. The Grouper is more of a bottom fish than the red snapper, for it swims much more slowly and very seldom rises to the surface. It is very voracious, consuming, as is shown by an examination of the contents of its stomach, enormous quantities of crustaceans and small fish. Large horny crabs in almost perfect condition are often found inside of it. Its movements are rather slow, and when hooked it is hauled up more like a dead-weight than like a line-fish. In South Florida it is extensively eaten when procurable, and at Key West it is particularly important, since a large fleet of smacks is constantly employed in carrying fares of Groupers to Cuba. In West Florida, where red snappers are more abundant, Groupers are not in demand and have but a small market value. After being taken from the water, the Grouper is remarkably tenacious of life, and will live several hours, even though exposed to considerable heat. This is one reason why the Key West fleet prefer Groupers for transportation to Cuba, since they are obliged to go a long way to market and through warm water, and no other fish of the kind would bear crowding and chafing in the wells of the smacks The Grouper attains the weight of forty pounds, and is an excellent food-fish."

In Cuba this fish is called by the Spanish name "Cherna." The name "Grouper" is a corruption of "Garoupa," a name given by the Portuguese to similar species. In DeKay's time, as has been remarked, this fish was not unusual in the New York market, where it sold for from six to twelve cents a pound, though its flesh was considered tough and not very highly esteemed. Gill, writing of the same market in 1856, states: "This species is sometimes sent to our market from Key West and the reefs of Florida in May and the summer months. I have never seen more than two or three exposed for sale at a single time; it appears to be considerably esteemed, and is sold at from twelve to fifteen cents a pound."

Genio Scott writes: "The Grouper is an excellent dinner-fish, and when boiled and served with drawn butter and shrimp or lobster sauce is said to fully equal the turbot."

The Black Grouper—Epinephelus nigritus.

The Black Grouper, *Epinephelus nigritus*, called in Florida and Texas the "Jew-fish," is at Pensacola known by the name "Warsaw," evidently a corruption of the Spanish name "Guasa." It was first brought to notice by Holbrook, who had received one specimen from the vicinity of Charleston; north of that point it had not yet been observed, though it appears to be abundant along the coast of East Florida and in the Gulf of Mexico. Mr. S. C. Clarke has observed it in the Indian River region, and has communicated the following notes to Professor Baird:

"The Black Grouper is resident all the year, though not abundant. The greatest size attained is about fifteen pounds; the average, three pounds. They pass the winter in the salt-water rivers, living in holes in the rocks and under roots and snags and about piles. They are solitary in their habits. They feed on small fish, particularly mullet, and on crustaceans, and breed in the salt rivers in May and June. Their spawn is very small, and pale yellow. They are taken with hook and line by the use of mullet and crab bait, and are seldom seen except when thus captured. They are much esteemed as food."

Mr. Stearns remarks that it is a common fish at sea along the Gulf coast, living chiefly on the same spots with snappers and Groupers. At some places it is found in abundance in the bays, and lives on the bottom, feeding upon small fishes, crabs, etc. On the fishing grounds where fish are being caught rapidly it not unusually occurs.

A very large Jew-fish will follow and finally swallow a hooked fish, usually a red snapper, with hooks, lead, line and all. If the line does not then break the fish may be hauled in with gaffs. The Jew-fish attains an enormous size, and specimens weighing from eighty to one hundred pounds

have been caught. The smaller fish are quite choice, but large ones are too coarse and tough to be salable.

There is another fish which is also called "Jew-fish," or "Warsaw," and "Black Grouper," of which only enormously large specimens have been obtained, and which is entered upon our catalogues under the name *Promicrops guasa*. It is a fair question whether this great fish be not the adult of the common Black Grouper or some closely allied species, the appearance of which has become somewhat changed with age. A large specimen, weighing about three hundred pounds, was taken near the Saint John's bar in March or April, 1874, by James Arnold. It was shipped by Mr. Hudson, a fish-dealer in Savannah, to Mr. Blackford, who presented it to the Smithsonian Institution. A fine cast of this specimen in papier-maché graces the cast-room of the National Museum. Professor Poey, by whom this species was named, states that in Cuba it attains to the weight of six hundred pounds. An old Connecticut fisherman, who was for many years engaged in the Savannah market fishery, states that the Savannah smacks often catch Jew-fish. They are so voracious that when put into the well with the Groupers they would do much damage. The fishermen have therefore found it necessary to sew their jaws together before placing them with other fish.

The Spotted Hind—Epinephelus Drummond-Hayi.

The Spotted Hind of the Gulf of Mexico, *Epinephelus Drummond-Hayi*, has been but recently discovered, and has been observed only in the Gulf of Mexico and at the Bermudas. It was observed at the Bermudas in 1851 by Col. H. M. Drummond-Hay, of the British army. Specimens were sent to the National Museum in 1876 and 1877 by Mr. Blackford and Mr. Stearns. It is one of the many important species which have been brought to notice by the labors of the United States Fish Commission. Although it is an excellent food-fish, it is even now not well appreciated.

Mr. Stearns records the following facts concerning its habits: "The Spotted Hind is common in company with the Grouper and the Jew-fish, and is most abundant in South Florida about the reefs. Off Pensacola it lives in the deep fishing grounds, in seventeen, nineteen, and twenty-two fathoms. It swims close to the bottom, and is of sluggish movements. I have not known of its occurrence in the bays, and believe that it spawns at sea. Specimens weighing fifty pounds have been caught, but that is fully four times the average size. It is seen daily in the Key West market and sells readily, but at Pensacola, Mobile, and New Orleans it is hardly marketable. Its color varies very considerably with the different colored bottoms on which it lives."

The Coney, *Epinephelus apua*, of Key West, the Hind of Bermuda, is an important food-fish which occurs throughout the West Indies. Specimens have been sent by Mr. Stearns, who recorded that it is common in South Florida among the reefs, and is often seen in the Key West market, where it is readily sold.

The Banded Grouper—Epinephulus striatus and others.

The common Grouper of Bermuda, *Epinephelus striatus*, one of the most important food-fishes of those islands, is sure to be found in the vicinity of Key West, and will probably prove to be one of the important fishes of our own southern coasts. About Key West and in the Gulf there are several species of the sub-genus *Myctroperca*, which may be grouped together under the name "Rock-fish," the name by which all fishes of this genus are also known in Bermuda. They are large fishes of excellent food quality, similar in habits to the others of the family which have already been discussed. The material at present on hand is not sufficient to admit of satisfactory identification of all the species. The "Black Grouper" of Pensacola, which has been variously

named *Mycteroperca brunnea*, *M. microlepis*, *and M. stomias*, is said by Mr. Stearns to be common in company with the Red Grouper, although not so abundant. It spawns in June and July, at sea and in the inlets. As a food-fish it is considered superior to the Red Grouper, although it is not more readily sold. It attains a weight of fifty pounds. Professor Jordan is of the opinion that the form recently described by Goode and Bean as *M. stomias* is the adult of that previously characterized by them under the name *M. microlepis*.

The Rock-fish of Key West, which has not yet been identified, is said by Mr. Stearns to be very common, and is sold almost every day in the market. The average weight is four or five pounds, the maximum twenty-five to thirty. There appear to be, from Mr. Stearns' notes, at Key West, as well as in Bermuda, various local forms closely related to this, one of which is known by the name "Gag"; another fish of this genus, *Mycteroperca falcata*, is called at Pensacola by the name "Scamp." It is common off the Florida coast, living near the bottom in company with the other species of Groupers. It is found on the coast all the year round, and is caught with hook and line. It seldom exceeds the weight of twenty pounds, and the average size is much smaller. It is considered an excellent table fish.

Several of these fishes, whose relations have not yet been determined, have been taken along the Atlantic coast, particularly at the mouth of the Chesapeake and at Wood's Holl, Massachusetts.

There are several other species belonging to this family which have been observed, none of which, however, are of any economic importance.

138. THE SERRANOID FISHES OF THE PACIFIC COAST.

By David S. Jordan.

The Jew-fish—Stereolepis gigas.

This species is everywhere known as the "Jew-fish." It is also sometimes called the "Black Sea Bass." It reaches a weight of five hundred pounds, being the largest food-fish on the coast. It ranges from the Farallones to below San Diego, and is generally abundant in deep water about the islands, but from its great size is seldom taken. It feeds upon smaller fishes, and is voracious. It is often taken by swallowing a white-fish when the latter is on the hook. Its flesh is of excellent quality, and those small enough to be available always bring a very high price in the market.

The Cabrilla—Serranus clathratus.

This species is called at Monterey, where it is not common, the "Kelp Salmon"; farther South it is known to the "Americans" usually as "Rock Bass," and to the Italians and Spaniards as "Cabrilla," a name applied to other species of Serranus in the Mediterranean. The Chinese call it "Lockee Cod" (Rock Cod). It reaches a length of eighteen inches and a weight of about five pounds. It ranges from San Francisco to Cerros Island, being very abundant about the Santa Barbara Islands, where it is taken in large numbers. It lives in water of no great depth, chiefly about the rocks. It feeds on squid, crustacea, and small fishes. It is an excellent food-fish, similar in quality to the related Atlantic species.

The Johnny Verde—Serranus nebulifer (Grd.) Steind.

This species receives the name "Rock Bass" and "Cabrilla" with the other species. The distinctive Spanish name of "Johnny (Juan) Verde" is also in frequent use, especially at San Pedro. It reaches a length of twelve to twenty inches and a weight of about five pounds. Most individuals seen are, however, small, not averaging two pounds. It has been taken at Monterey, but it is common only from San Pedro southward to Magdalena Bay. So far as known to us, it agrees in habits and value with the preceding.

THE SPOTTED CABRILLA—SERRANUS MACULOFASCIATUS Steindachner.

This species receives the same names, "Rock Bass" and "Cabrilla," as the others. It agrees with the preceding in value, distribution, and habits, so far as known. Its a rather smaller size. It is an excellent food-fish, and from its great abundance about San Diego it may become of considerable economic importance. Its range extends southward to Mazatlan, it being one of the very few California fishes which extend their range to the south of the Tropic of Cancer.

139. THE YELLOW PERCH—PERCA AMERICANA.

"Wherever found," writes Jordan, "this species is the Perch *par excellence*," the name *Perch* being elsewhere wrongly applied to various Serranoid, Sciænoid, Centrarchoid, and Embiotocoid fishes. The descriptive names "Yellow Perch" and "Ringed Perch" are in common use. The Perch is found throughout the Great Lake region, the rivers of New England and of the States east of the Alleghany Mountains as far south as Georgia. It occurs in some tributaries of the Ohio in the northern parts of Ohio and Indiana, and of the Mississippi in Wisconsin and Minnesota, but throughout the lower basin of the Mississippi and the west slope of the Alleghanies it is entirely absent. The Perch is one of the common market fish of the North and East. Its usual length is about a foot, and its weight generally less than two pounds. It is a fish of fair but not excellent quality. It is a carnivorous fish, feeding on minnows, etc., and usually freely taking the hook. It spawns in spring. Dr. Steindachner, of Vienna, has recently attempted to demonstrate the identity of the American Perch with the similar species in Europe, but this I cannot admit, for they are no more alike than various of our species of *Lepomis*, *Amiurus*, etc. It is true enough that the distinctive characters noticed by Steindachner are unreliable, but, so far as I have seen, they differ strongly in gill-rakers, pseudobranchiæ, position of first dorsal, etc. Of course, no sane man doubts their community of origin, but different "species" they are now, or at least sub-species."

The following observations with regard to the abundance of the Yellow Perch, in the Great Lakes have been made by Mr. Ludwig Kumlien and others:

On the eastern shore of Minnesota, and especially about Duluth and vicinity, these fish are common. On the southern shore of Lake Superior, as far east as Keeweenaw Point, and about the islands included—such as the Apostle Islands, Sand, York, and Rock Islands—they are also common. In this region they have been on the increase for the last ten years, being quite rare as lately as 1870. They are, however, never shipped to the large markets, being used for home consumption. In the small bays running southeast from Keweenaw Point Yellow Perch are very abundant; in this locality they are not found plentifully at a great distance from shore. In Marquette Harbor a few are taken in the herring seines, but none are caught in the pound-nets. The yellow-perch fishery is of no importance between this point and Sauk's Head.

At the north end of Green Bay Yellow Perch are not abundant. They are found chiefly in the mouths of the small bays included in Green Bay, and are said to be rare about the islands; they are not taken in the pound-nets at least. Toward Cedar River this fish is not plentiful, being taken almost entirely in the shoal-nets. A little farther south, about the mouth of Menomonee River, there is a greater abundance of them; here also they are taken in some quantities in the inshore nets. They are shipped from here with the "dory," but complaint is made by the dealers if there is too large a proportion of Perch. When shipped separate they command a low price. Writing on September 24, 1880, Mr. Kumlien remarks: "I have seen a good many that were taken near Menomonee River within the last few days and was surprised at their small and uniform size; few of them would exceed eight inches. The fishermen inform me that there has been a run of these small Perch since last winter in excess of anything ever known in previous years."

The fishermen are under the impression that Perch instead of white-fish were hatched out and deposited here by the State Fish Commission.

Between the Menomonee River and Oconto Bay this fish is common, but of little importance. It brings a low price and is not sought after. It is caught inshore in the sloughs. At the southern extremity of Green Bay the Yellow Perch is abundant. All along the eastern shore of Green Bay it is very plentiful; there has been a greater abundance of it during the past year (1880) than ever before.

Along the western shore of Lake Michigan, as far as Manitowoc, the Yellow Perch is extremely rare, except about Two Rivers and Manitowoc, at which two points it is common and meets with a ready sale. Between Manitowoc and Port Washington the Yellow Perch occurs very sparingly, especially in the vicinity of Cedar Grove. The other fishing grounds between the above-named points are White Fish Bay, and Sheboygan.

In the vicinity of Milwaukee this fish is extraordinarily abundant, and was especially so during 1879. In less than ten fathoms they are sometimes caught in the gill-net; the majority, however, are taken on hooks. They are of considerable importance in this locality and meet with a ready sale. At Racine a great many, and of a large size, are caught. At Waukegan, a little farther south, they are especially abundant in June and July. They were more plentiful in 1879 than they had ever been before.

At the southern end of Lake Michigan, about New Buffalo and Michigan City, they are abundant, being caught on hooks and sold in large numbers to the railway baggage-men, who peddle them on the cars. They have been more abundant this year (1880) than ever before. The finest specimens are caught as far out from shore as fifteen miles, but the smaller ones do not go out so far. Many are shipped to the Chicago market.

Around the docks of Saint Joseph, at the southern end of Lake Michigan, the yellow perch fry fairly swarms. In the summer of 1880, two hundred hooks were set two miles out from shore; each hook had a Perch, some weighing as high as two pounds. From Saint Joseph Yellow Perch are often shipped with white-fish and trout. They are chiefly caught in gill-nets, several miles from shore.

On the eastern shore of Lake Michigan, about Ludington and Manistee, they were as plentiful as ever before in 1880; some years they are less common, and then come on again. At Grand Haven they were less abundant than usual, and are seldom taken at this point at any great distance from shore. About Little and Great Traverse Bays and the Fox Islands they are generally common, but were less plentiful in 1880 than ever before. They are occasionally taken in the pound nets, and even in the gill-nets, but are of no commercial importance.

The Yellow Perch is reported as common at the northeast end of Lake Michigan, through the Straits of Mackinaw, and down the western shore of Lake Huron to Thunder Bay. Captain Dingman, who appears to be well informed as to the fisheries of that region, says they are not one-tenth as numerous as they were in 1879. If this be true of the northeastern shore of Lake Michigan, it may account for their being unusually numerous on the opposite (western) shore of that lake. Near the Les Cheneaux Islands a large variety is reported as having been caught. Yellow Perch are more common about these islands than generally along the shore. They are not often taken in the deep pounds but are quite abundant in shallow water and in the small lakes.

In Thunder Bay Yellow Perch are abundant, and are taken principally in the pound-nets in spring. Mr. Case thinks they are increasing. Very few are shipped from this point; during 1879 not over five hundred, in which year the run was very large.

In the rivers running into Saginaw Bay Yellow Perch are abundant, but not so much so as

formerly. Mr. Riker thinks they have left the rivers for the bay, during the last few years, to a great extent. From places on this bay they are shipped as soft fish. Down from Saginaw Bay to Port Huron, the remainder of the western shore of Lake Huron, Yellow Perch are very abundant, as also in the Saint Clair River; Mr. Canham thinks that they are on the steady increase. From this region few are shipped, the demand being principally local, but outside markets are springing up. A good many are taken on the lake shore in the bait-nets.

On the fishing grounds at the west end of Lake Erie, from Toledo to the mouth of the Detroit River, including the pound fisheries of the last named locality, Yellow Perch are said to be very abundant and on the increase. They are usually dressed (skinned) and sent to inland towns. There is a great demand for them by the peddlers who supply the farms.

About the vicinity of Maumee Bay and Toledo, and in Maumee Bay, Yellow Perch are very abundant at all times. In late autumn and winter a few are shipped to New York City. East of Port Clinton the pounds do not catch any, though they are very abundant in the Sandusky River and small bays adjacent. About Toussaint and Locust Point a few are caught in spring in the pounds, but are thrown overboard.

In Sandusky Bay, Upper and Lower, and in the lake between Ottawa City, on Catawba Island, and the Huron fisheries, Yellow Perch are very abundant in early spring and late fall. At Sandusky they are very abundant, and it is thought that the offal thrown into the lake helps to keep them in that locality. They are usually counted as "rough" fish and sold with the herring, but are sometimes counted as "soft" fish early in the season. A very large variety is taken outside of Sandusky Bay in the lake, and Mr. Stoll, one of the authorities of that district, affirms that the lake and marsh varieties are distinct. About the islands of this region Yellow Perch are common, and, according to Mr. Anthony, from five to ten tons have been caught there, several years ago, at one lift.

In the fishing grounds at Huron, Ohio, on the south shore of Lake Erie, this species is abundant. Six or seven years ago few were taken in the lake pounds in comparison with the numbers taken in them at the present day. About nine-tenths of those now taken are thrown away. A few are shipped to New York City in late autumn, and a few are frozen. Yellow Perch, in this locality, are not even graded as a soft fish, and seldom bring more than do the sheepsheads.

Yellow Perch are very abundant at Vermillion, Ohio. Ten tons have been caught in a day and set at liberty for lack of demand. A few tons of the late autumn catch is generally frozen. Here they do not even count as a soft fish, but sell separately, and rarely for a higher price than the sheepshead. The Yellow Perch are here of a uniform size, averaging about three-fourths of a pound apiece.

At Black River and Amherst this species is very common; they are classed as soft fish, but are not considered a "good" soft fish. They are most abundant in the spring—usually in April—but unimportant. At these points the Yellow Perch average a large size.

This species is very abundant during some years at Cleveland and Dover Bay, Ohio, and again for some time but few are taken. They are most plentiful in spring, during which season of the year as high as two or three hundred pounds are taken in a day. When abundant, they have a poor sale, but when a few only are in the Cleveland market they command a fair price. They are of uniform size, and average about three-quarters of a pound.

At Conneaut and Ashtabula Yellow Perch are abundant and quite important. They are taken in gill-nets in winter as far as eight miles from shore. In May, when they spawn, few are caught over a mile from shore. At Painesville Yellow Perch are not so common as east and west of that place. At Dunkirk and Barcelona, New York, this species is very abundant, and especially

so at Erie, Pennsylvania, where it is considered as of great importance. Off Erie Bay a very large grade of this fish occurs. Many are taken in gill-nets. At Oswego, Port Ontario, Lake Vincent, Chaumont, and Sacket's Harbor, and other points on the southern and eastern shores of Lake Ontario, Yellow Perch are very abundant. At Port Ontario they are of some commercial importance and are more highly prized as a food-fish than is usual, as is also the case at Lake Vincent, where they are more highly prized than the sun-fish. From Chaumont they are shipped in spring and winter as "Perch." At Lake Vincent they are known as "Striped Perch." At Sacket's Harbor they are of no special importance.

Mr. Eveland says he has frequently caught Yellow Perch weighing two pounds. They are seldom found in water deeper than from twenty-five to thirty feet. It is a prevalent belief among fishermen that Yellow Perch are very destructive of white-fish. Mr. Hatch thinks that the decrease of the latter may be to some extent due to increase of the former. Perch caught in the Lakes are much larger than those caught in the rivers running into them.

140. THE LOG PERCH—PERCINA CAPRODES (RAF.) GRD.

By DAVID S. JORDAN.

This species is known as the "Rock-fish," "Hog-fish," or "Log Perch." It is the largest of a large group of little perch-like fishes known as "Darters" or *Etheostomatidæ*. These fishes may be described as little perch, reduced in size and compacted, thus fitted for a life in rocky brooks where the water is too shallow, swift, and sterile to support larger fish. All the Darters are brilliantly colored, and all have a way of lying quiescent on the bottoms, resting on their large fins, and then suddenly darting away for a short distance when disturbed. They are carnivorous, feeding chiefly on insects and crustaceans. Only one of them (*Percina caprodes*) is large enough to take the hook. This one is often found on the urchin's string, but it cannot be said to have any economic value. The others are too small for the urchin even, and although, according to Rafinesque, "they are good to eat fried," few people think it worth while to cook them. Darters are found in all fresh waters of the United States east of the Rocky Mountains, but all the species are peculiar to America.

141. THE PIKE PERCHES.

In the interior of North America occur two species of the genus *Stizostedium*, the Wall-eyed Pike, *S. vitreum* (Mitch.), J. & G., and *S. canadense* (Smith) Jordan. Both of these occur in the Great Lake region and the Upper Mississippi, and the valley of the Ohio and the Tennessee; the former penetrating northward to the fur countries, and into some of the Atlantic streams south of New England.

"*S. vitreum*," according to Jordan, "may be readily known from *S. canadense* by the presence of a single black spot on the posterior part of the spinous dorsal, instead of one or two rows of smaller spots on the middle part of the fin."

THE WALL-EYED PIKE OR DORY—STIZOSTEDIUM VITREUM.

"*Stizostedium vitreum*," writes Jordan, "is most commonly called the 'Wall-eyed Pike.' In the Upper Lakes, where the true Pike (*Esox lucius*) is known as 'Pickerel,' the Wall-eyed Pike becomes simply 'Pike.' The names 'Glass-eye' and 'Yellow Pike' are sometimes heard, and the name 'Blue Pike' is applied to a local variety. The name 'Pike Perch,' a translation of *Lucioperca*, a name given by Cuvier to the genus *Stizostedium*, is often used in books, but has never taken root among fishermen. Among the French about Lake Michigan and in Canada

the name 'Dory' is in common use. Southward the name 'Jack' is applied to this species as well as to the Pike. The most unfortunate misnomer of 'Salmon' is also common in the South, and the names 'Okow,' 'Blow-fish,' "Green Pike," and 'Jack Salmon' are also current in various localities. This species is very abundant throughout the Great Lake region and the Upper Mississippi and Missouri. It has also an extensive but not well-known distribution through the larger streams of the Southern States, at least of the upland portion. It feeds upon other fishes, and is a voracious and gamy species. It reaches a length of three feet or more, and a weight of fifteen to twenty-five pounds or more. Those seen in market are generally much smaller. This is one of the best of our food-fishes, with firm, white flesh of good flavor. In the markets supplied from the Great Lakes it ranks in importance below the white-fish and lake trout only. It is the most valuable of our fresh-water percoids."

Jordan recognizes two varieties of this species, namely, var. *vitreum* and var. *salmoneum;* the latter, known as the "Blue Pike," is a local variety in Ohio and southward; it is bluer in color, and is smaller, besides having the body shorter and deeper.

The abundance of the Wall eyed Pike, *Stizostedium vitreum*, in the region of the Great Lakes has been recorded by Mr. Kumlien as follows:

"At the western extremity of Lake Superior, at the head of Saint Louis Bay, Wall-eyed Pike are abundant. They are there taken extensively with seines. Off the Wisconsin coast of Lake Superior, and, passing east, as far as Ontonagon, Michigan, Pike have, within the last two years, become abundant. Four years ago the fishermen could scarcely find sufficient for their own tables, while in 1879 there was an immense "run" of Pike. They are most abundant in Squaw and Siscourt Bays and are of larger size than in Keweenaw Bay. The sudden appearance of Pike is a deep puzzle to the fishermen.

"At Portage Entry and L'Anse, Pike are abundant; they are common, however, all along the shore from Ontonagon to Huron Bay, between which two points they rank third, and would take the second place (*i. e.*, that of lake trout) if the "runs" of Pike were as continuous as those of trout—which latter can be caught at all times. Pike are here taken principally in the pounds. They average a smaller size than in the Lower Lakes. At Portage Entry the fishermen used to keep the Pike in a pond until required for shipment. They are here called "Yellow Pike."

On the fishing grounds between Grand Island and Sauk's Head, including Ontario Bay, Sucker Bay, Laughing-fish Point, Short Point, Marquette and Big Presque Isle, Pike are taken to some extent, but are not abundant enough to be of much importance. Twelve years ago they were quite rare; they have since that time been increasing steadily. They are taken in the pound-nets to some extent, but rarely in the gill-nets. Some pounds do not get half a dozen to a lift. In this region they are known as "Yellow Pike," as also at White-fish Point, where they are sometimes taken at the rate of two or three hundred pounds at a lift, but are not plentiful.

At the north end of Green Bay the name "Doré" is given to this species. In this locality, including the fishing grounds of Escanaba, Chippewa Point, Summer Island, Saint Martin's Island, and Point aux Barques, they are equally abundant, and grow to a large size, occasionally weighing twenty pounds. They here rank third in importance, and are taken in gill-nets, except in winter and spring. Of late years they have been salted to some extent.

Along the shore of Green Bay, between the mouths of Cedar River and Peshtego River, they rank third in importance, the white-fish taking the first place and the sturgeon the second. They are taken more plentifully in the fall than in the spring, the reverse being the case at the head of the bay, where they spawn in great numbers. When shipped fresh they are not dressed at all. In spring they are, to some extent, salted, and are sold as "Salt Pickerel." This business of

salting was carried on during the summer of 1880 along the whole western shore of Lake Michigan. In spring they are taken quite extensively on rocks in the Menomonee River, where they go to spawn. At this season many are taken with spears also, especially for home consumption. One man says he took five barrels in a night. They are prized very highly by the fishermen. In the deep-water nets a very large grade is caught. In this region they are known as "Dory."

Between Peshtego Point and Longtail Point they are called "Wall-eyed Pike" and "Dory," are of much importance, and greatly sought for. In this division of the western shore of Green Bay they are principally taken in gill-nets, but do not enter a pound-net well. The chief shipments of these fish salted take place between the 1st of April and the 15th of June, when they are shipped as "Salt Pickerel" to the Western markets; during the rest of the year they are shipped fresh, on ice. In 1878 one was taken at Oconto weighing nineteen pounds. They spawn early in spring, and are considered destructive to young fish and spawn. In scaling the fish a common curry-comb is used. This fish and the White Bass are the two most important kinds taken at the Green Bay City fisheries, where the former is called "Dory."

Along the eastern shore of Green Bay the Pike is not, as on the western shore, abundant. About Little Sturgeon Bay two and three a week are considered the average number taken. One kind only is recognized between Bay Settlement and the island of Saint Martin. Between Port des Morts and Manitowoc, on the western shore of Lake Michigan, Pike are rare, and the few caught are taken in the spring. Mr. Kirtland took three packages of Pike at Jacksonport in 1879. At Two Rivers they only occur as stragglers. At Manitowoc the name "Pike" alone is used, "Dory" being unknown. They likewise only occur as stragglers at the fishing grounds between Manitowoc and White-fish Bay.

In the vicinity of Milwaukee they are by no means abundant; they are caught, when occurring, in pound-nets, but never in gill-nets. In the small inland lakes they are pronounced to be quite common. South of Milwaukee, as far as Evanstown, Illinois, they are far from abundant, but were formerly quite plentiful about Racine, though now nearly exterminated at that point. When shipped they are packed with the white-fish. In this region they are called "Yellow Pike." At the extreme south of Lake Michigan, including the New Buffalo and Michigan City fisheries, this species is called "Wall-eyed" Pike. It is rare, but taken at all seasons of the year. Three or four at a lift of the pound-net is the average. When shipped South it is called "Salmon." The size attained is large, probably averaging fully ten pounds.

At the Saugatuck, South Haven, and Saint Joseph fisheries, on the east shore of Lake Michigan, "Wall-eyed Pike" (as the species is there designated) are becoming more common of late. It is thought that they have, to a great extent, replaced the pickerel in the small lakes and river bayous. They are not yet of sufficient abundance to be of any commercial importance. Individuals of this species are here taken chiefly with hooks, and occur but sparingly in the lake.

At Ludington, Point Sable, Grand Haven, and other fishing towns, between Saugatuck and Glen Haven, Lebanon County, Pike are by no means abundant, being most plentiful in August at Ludington and Manistee. White Hall is an exceptional place, wagon-loads being sometimes exposed on the streets for sale. At Grand Haven not more than half a dozen a year are caught in the lake, but in the Grand River they are not at all rare.

On the fishing grounds of Little and Grand Traverse Bays, and about Fox Islands, Pike are extremely rare. They are occasionally found in Grand Traverse Bay, but are scarcely at all known by the fish authorities of that region. In the fishing grounds comprised between Little Traverse Bay (passing north and east through the Straits of Mackinaw as far down the western shore of Lake Huron as Hammond's Bay) and Adams Point the name "Pickerel" is given to this species,

except by the French fishermen, who call it "Dory." Throughout this region this fish is common, but principally in the rivers and bayous. Mr. Bennett reports thirteen hundred pounds from one pound-net in two nights in Hammond Bay. This fish is by far the most plentiful in spring. It is much sought for because of its good keeping qualities. About Mud Lake and in the Sault Ste. Marie River this species is quite extensively fished for and is sold separately. In the outer pounds in the lake (Huron) not many are caught. The majority of fishermen salt them and sell as "Salted Pickerel"; the proportion of this fish to white-fish is about as one to one hundred.

At Alpena, Thunder Bay, Pike, usually here called "Yellow Pike," form quite an important fishery during May and June, after which but few are taken until September. The largest lift known here was in 1874, when three thousand were taken from one net in a single lift. During September very few of any other kind than Pike are taken in the pound-nets. In comparison with Saginaw Bay, but few are taken at Alpena.

In Saginaw Bay this species, known as "Yellow Pike," "Pickerel," and "Wall-eyed Pike," is thus spoken of in a circular by Riker & Kelbourn: "Saginaw Bay produces more fish yearly than any equal extent of inland water in the United States, and of as good quality, and in one notable exception a good deal better. This is the Yellow Pike, or what are termed South 'Lake Salmon,' and on Lake Erie are known as 'Pickerel.' They are a harder, firmer, fish, and will bear transportation better, and keep longer, than pickerel caught in the Lower Lakes. Because of these qualities, and their superior adaptation for the use of the table, they are regarded South and West as the fish first of all desired. This immense catch of fish is prepared for shipment, in parcels to suit customers, to the East, South, and West, embracing several States."

The "Pickerel" is the most abundant and important fish in Saginaw Bay. Besides those taken in the pounds and with seines, large quantities are speared in winter through the ice. In spring they are taken till July, and then very few are caught again till the latter part of August. It is presumed they go into deep water during the warmest weather. In spearing them through the ice a decoy fish is used to lure them within reach; they are very rarely taken in the gill nets. There seems to be no very alarming decrease among them, yet it is readily admitted that they have been more plenty than they are at present. Spawn in the bay during April.

From Point aux Barques to Port Huron, Pike are very abundant, and are the most important fish in the Saint Clair River on the Canada side, where they are of great commercial value. They are here known as "Yellow Pickerel." It is an interesting question why they should be more abundant on the Canadian than on the American side. Saginaw Bay is the hot-bed for this species, and from there they seem to strike across the lake to the Canada shore, entirely avoiding the east shore of the peninsula from Point aux Barques to Port Huron. When they come into the Saint Clair River they follow close to the Canada shore, and return the same way.

Between Toledo and the mouth of Detroit River, Pike, called "Yellow Pickerel" in this region, are not abundant. Unlike Maumee Bay, they do not seem to delight in this western shore of Lake Erie. The runs occur in places in the spring irregularly, and no dependence is placed on a fair supply at any time. It is not considered one of the important fish.

In Maumee Bay Pike are very abundant. Early in the season large quantities come from the bay and river of the same name. They rank second in importance, and are exclusively salted, being then known as "Salmon," otherwise as "Yellow Pike." In autumn few are taken in comparison with the number caught in the spring. Pike, or "Yellow Pike," here called, strike on the south shore of Lake Erie, around Port Clinton, about April 1, and stay only a few days. They rank about fourth at that place. At Locust Point they are caught in considerable numbers in spring, and some in fall also. Here they rank third in importance.

At all the fishing points between Ottawa City, on Catawba Island, and the Huron fisheries, with the neighboring islands, the greater part of the "Pickerel" are called "Gray Pickerel," and many say that they are totally different from the "Yellow" or "Blue" Pickerel. In Sandusky Bay they are particularly abundant; also about the islands and in the harbors. They have extensive spawning grounds at Cedar Point, Marblehead, Spit Island, East and West Harbors, Mouse Island, Sugar Bluff, Moose's Point, North and Middle Bass Islands, Put-in Bay, and Kelley's Island. They are sold as hard fish, and usually run large. When less than a pound they are sold with the "Saugers."

Connected with the Huron (Ohio) fisheries, the Pike, here called "Yellow Pike," are considered quite important, but not so abundant as farther west. They are caught principally in the spring, and are thought to work westward toward Maumee Bay about their spawning time. They rank about fourth in importance. The general impression among fishermen here is that the true Yellow Pike is not caught at all here—by which they mean the Yellow Pike of Saginaw Bay. Many call this fish the "Gray Pike," and yet consider it an entirely different fish from the "Blue Pike."

At Vermillion, Ohio, there is caught, early in the spring, what is termed the "Spawn Pike," running from twenty to thirty pounds. Later the runs average much smaller—one to five pounds—and these are supposed not to spawn. Pike here are not abundant, and it is only in the spring that they are regarded as important.

A little farther east, including the fisheries of Black River, Amherst, and Brownhelm Bay, "Yellow Pike," so called in this section, are not abundant. They are taken early in spring. On account of their fewness they are of but little importance. There is said to be too much waste in dressing to make them a salable fish among the poorer classes. The markets are never glutted with this fish. None are salted. At Cleveland and Dover, Ohio, this species is known as "Yellow Pickerel" and "Pickerel." At the Dover Bay fisheries they are not abundant, in the largest lifts not over one hundred and fifty to two hundred pounds being taken. They are caught principally in early spring, and range from one to five pounds. Until the last six years this fish was unknown here. Farther east, at Conneaut and Ashtabula, "Yellow Pike," as they are there called, do not seem to be common; a few large ones (from ten to twelve pounds) are taken every season. About Painesville, Fairport, and Willoughby this species is known as "Yellow Pickerel." They are not very common; some are taken in spring. In 1879 not over two tons were taken in sixteen nets. They are much more common farther west. Years ago they were abundant and one of the most important of fish, but since the dynamite explosion at Fairport (the port of Painesville, three miles from the city, on the lake shore), about eight years ago, they have been rare, and the fishermen think the explosion—which was so strong that it broke window-lights in Cleveland and Buffalo—drove them away. A decrease in other species was noticeable for some time afterwards. Those taken at Painesville are remarkably dark colored, much darker than those taken at the islands.

When pound-nets were used in the fisheries of Dunkirk and Barcelona, New York, Erie, Pennsylvania, and Mill's Grove, Ohio, a good many Pike were taken; even now a few are taken in the gill-nets. At the above places they are called "Wall-eyed Pike."

Concerning the Lake Ontario pike fishery, we learn that at Oswego they are fairly common and rank third in importance. At Port Ontario they are known as "Yellow Pike." They were formerly abundant at this point, but of late years few have been taken. Since pound-net fishing began they have gradually grown less abundant—been "caught out." A few are yet taken in the seines.

At Cape Vincent Pike are abundant. The fish of one variety, with a longer and more pointed head than the Upper Lake fish, are called "Spike-noses." They rank second in commercial impor-

tance. They are brought over from Canada to a great extent, but the bulk that is shipped from Cape Vincent is caught in American waters. They are common everywhere. At Chaumont they rank first in commercial importance. The largest runs occur in the bay in early spring. Pike do not come as near shore as formerly. At Sacket's Harbor they rank first in importance, and are caught in the spring as soon as the ice is out, and in fall till winter sets in. During the winter they are brought from Canada. It is thought that they have increased since the alewives came here, and that the average weight now is one-third greater than ten years ago.

It is said that Yellow Pike, *Stizostedium vitreum*, can be confined in a small pond much more successfully than most species. They are said to prefer the vicinity of river mouths, and not to go far out into the lakes.

The following facts concerning the abundance of the Blue Pike, identified as *Stizostedium vitreum* var. *salmoneum*, in the region of the Great Lakes, were gathered by Mr. Kumlien:

In the fishing grounds of the west end of Lake Erie "Blue Pickerel" are known only as rare stragglers. In the vicinity of Toledo and Maumee Bay Blue Pike are very seldom seen. At some of the principal fisheries not more than one in a year is taken. This fish is generally not recognized by the local fishermen. On the south coast also, at Port Clinton and Locust Point, this fish is a great rarity, and only appears as a straggler. It is of no importance whatever.

About Upper and Lower Sandusky Bay, and all the fishing grounds between Ottawa City and Catawba Island to the Huron fisheries, the Blue Pike are abundant from May till June 5, the largest runs occurring from the 20th of May until June. They rank in this region about fifth in importance. They are sold fresh, frozen and salted, about half the catch being salted and sold as "Medium Pickerel." It is somewhat improbable that individuals exceed one and a half or two pounds in weight. They are less abundant around the islands, among which may be named Spit Island, Mouse Island, North Bass Island, Middle Bass Island, and Kelley's Island. The "Gray," "Yellow," and "Blue" Pike grade into each other in this locality in such a manner that it is hard to draw the limiting line. Mr. Kumlien thinks that all of these represented as "Gray" and some "Blue" were *S. vitreum*, but that the bulk of those called "Blue" are readily distinguishable from *S. vitreum*.

In the Huron (Ohio) fisheries Blue Pike are extraordinarily abundant, in fact too much so. Such quantities are sometimes caught that not one-quarter can be made use of. The largest runs come on late when the market is already full, consequently a very low price is realized for them. A few are taken in early spring, as soon as the fishing begins, but the bulk are caught from the 12th to the 20th of May. As high as one hundred and fifty tons have been brought to Huron in a day. They are largely salted. The average weight is about a pound, though some are taken in early spring weighing ten to fifteen pounds. The direction of the movement made by the Blue Pike is supposed to be easterly in the spring, when they start from the vicinity of the islands, returning (westward) in the fall. Between Cedar Point (east side entrance to Sandusky Bay) and Black River they occur in greater numbers than at any other point in Lake Erie. Some are caught in autumn, but the catch then is nothing as compared with that of late spring.

At Vermillion, Ohio, the Blue Pike are more abundant than any other species, and rank second in importance. They are taken as soon as the fishing commences, but from the 24th of May till June 1 to 6 they come in such myriads that it is impossible to take care of them, and tons upon tons are let out of the nets. The average weight is about a pound, but specimens weighing as high as fifteen pounds are said to be taken early in spring among the spawning Yellow Pike. This fish was formerly graded as "hard," but of late years they have been classed "soft," principally on account of their numbers, but also because in flavor they are far inferior to the Yellow Pike. They come into

the nets in such quantities, and at a season when the market is already full, that they are often sold for the freight charges only. Mr. McGraw thinks there is an appreciable increase in their numbers each year. In 1879 as high as four tons were taken from one pound at a single lift. When salted they are called "Medium" and "No. 2 Pickerel." The reason so few are salted in proportion to the amount caught is on account of the low price realized for them, coming, as they do, into competition with more valuable kinds. From the following it will be seen that the profits to the fishermen are very small:

Cost of packing 100 pounds salt fish ready for market: Half barrel, 35 cents; dressing fish, 12 cents; salt, 15 cents; salting, 10 cents; inspection, 25 cents; total, 97 cents. Then add cost of from 160 to 175 pounds of undressed fish, and sell for $1.50 per half barrel, and the profits are very small.

At Black River, Amherst, and Brownhelm, Ohio, the most important fish is the Blue Pike. The largest runs occur in May and October. Mr. Freund thinks that they spawn in June or the latter days of May. The general impression amongst the fishermen is that they do not spawn, as none of them have seen the spawn in the fish. Such quantities are sometimes taken that it is very difficult to take care of them all. They are used fresh, and are also salted.

At Cleveland and the Dover Bay fisheries the Blue Pike is the principal fish and very abundant. They are taken as soon as the fishermen get their nets in, but more plentifully at the end of spring and fall than at the beginning of those two seasons. It often happens that such quantities are taken that they cannot be disposed of. They appear to be increasing every year; as high as twenty tons are reported from four nets in one day. About one-fourth of the catch is salted; the fishermen say that the early-caught fish do not salt so well as those taken later. The average weight is about one pound, those coming on first in spring averaging, perhaps, less than this weight, but the late runs are larger. It is said that specimens have been caught among the islands at the west end of the lake weighing fifteen pounds. All the fishermen say they never saw one with ripe spawn. Formerly they were classed as "hard fish," but now they sell as "soft."

At Oswego this species is called "Gray Pike," is quite common, and unusually silvery in appearance. At Cape Vincent they are known only as stragglers. At Chaumont they are very rare, and at Sacket's Harbor very few are caught.

The "Jack" on the Ohio River, as described by Jordan in the lately published report on the fishes of Ohio, reaches occasionally forty pounds. "It possesses great activity and strength, and is a ravenous destroyer of Perch and other species. Were it not so superior in every way to others, this habit might condemn it; as it is, we regard it as one of the best species we possess. In the South it is eagerly bought, and forms the principal table fish for the various places of resort, where it can be obtained."[1] "The 'Blue Pike,'" says Jordan, "is said to frequent only bayous and inlets, not being taken in the deeper waters of the Lakes, where *S. vitreum* especially abound. It also reaches a smaller size, according to Mr. Klippart, who asks, 'Why does the Blue Pike frequent the bayous and get to be no more than twelve to fifteen inches in length, and to weigh not to exceed two or three pounds, if it is identical with the Wall-eyed Pike which frequents the deep waters of the lake and attains a length of three feet and a weight of eighteen to twenty pounds?' This species, according to Mr. Klippart, is at the Lake Erie fisheries split and salted with the Sauger, *S. canadense*, the two together being known to the commercial world as 'Pickerel No. 2,' and bringing about two-thirds the price of Pickerel No. 1, which is *S. vitreum*."[2]

[1] Cope, Rept. Comm. Fish Penn., 1881, 128.
[2] Geological Survey of Ohio, iv, part i, p. 64.

THE SAUGER.—STIZOSTEDIUM CANADENSE.

The "Sauger," known also as the "Gray Pike," "Sand Pike," "Ground Pike," "Pickering," "Pickerel," and "Horse-fish," has its habitat, according to Jordan, in the Saint Lawrence River, *Great Lake region, Upper Mississippi, and Upper Missouri Rivers, also in the Ohio, where, according* to the fishermen, it has been introduced from the Lakes through the canals.

"The different form and coloration, particularly the markings of the dorsal fin," writes Jordan," distinguish this species at once from *Stizostedium vitreum*. This species has, moreover, always fewer dorsal rays, more scaly cheeks, and permanent armature of the operculum.

"*In comparing Saugers from widely separated localities certain differences appear, which are* perhaps sufficiently constant to indicate distinct varieties. Of these, three are perhaps worthy to be designated by name. The common Sauger or Sand Pike of the Lakes (*Lucioperca grisea* DeKay) should bear the name of *Stizostedium canadense*, var. *grisea*. The Sauger or Pickering of the Saint Lawrence was the original *Lucioperca canadensis* of Col. C. H. Smith. It should, therefore, be the typical variety, *canadensis*. Its head is rougher and more closely scaled, and the number of spinous points on the opercle is greater. The 'Sand Pike' of the Upper Missouri averages rather slender, with a long, slender nose and more flattened and snake-like head. This is the *Lucioperca borea* of Dr. Girard, and may be called var. *borcum*, if the difference here noted prove at all constant.

"The Sauger never reaches a large size, the largest I have seen being from fifteen to eighteen inches in length. It is abundant everywhere in the Great Lakes, and is valued as food, although less highly rated than its relative, the Pike Perch.

"It is plentiful in the Ohio River, where it is probably indigenous, although some claim that it has been introduced there through the canals."

Mr. Kumlien has collected many interesting notes concerning this as well as the preceding species. These will be printed at a future time.

THE STRIPED BASS FAMILY.

Fishes of this family are common on both sides of the North Atlantic. The Bass of Europe, *Roccus labrax*, is one of the favorite food-fishes of that region, and is found from Tromsoe, in Norway, latitude 70°, south to the Mediterranean, where it is abundant. A very closely related species is our own Striped Bass, or Rock-fish, *Roccus saxatilis*, which is found from the Gulf of Saint Lawrence to the Gulf of Mexico. *These two species are very similar in form, although the colors* are different, the American Bass being conspicuously striped, while that of Europe is silvery gray. They are both strong, active, and voracious fishes, and both ascend rivers, although the American Bass seems to be much more addicted to life in fresh water than its transatlantic relative, probably owing to the fact that our rivers are more numerous, larger, and much more plentifully stocked with the fish upon which the Bass rely for food. They ascend the Potomac to the Little Falls, the Hudson to Albany, the Connecticut to Hartford, and the Saint Lawrence to Quebec. Before the erection of dams in the Susquehanna individuals were taken as high up as Luzerne. Europe has two other species, which it is unnecessary to discuss here, and North America has three—the White Bass or Striped Lake Bass, *Roccus chrysops;* the Brassy Bass of the Lower Mississippi Valley, *Roccus interruptus;* and the White Perch of the Atlantic coast, *Roccus americanus*. All of these are of considerable economic importance, though the Striped Bass is beyond comparison more valuable than all the others together.

142. THE STRIPED BASS—ROCCUS LINEATUS.

GEOGRAPHICAL DISTRIBUTION.—The Striped Bass, as has been already stated, occurs in all the waters of our coast from latitude 50° to latitude 30°. In the North it is called the "Striped Bass," in the South the "Rock-fish" or the "Rock." The neutral territory where both these names are in use appears to be New Jersey. The fishermen of the Delaware use the latter name, those of the sea-coast the former. Large sea-going individuals are sometimes known in New England by the names "Green-head" and "Squid-hound." There is still some uncertainty regarding the southern limits of the distribution of this species. In the Saint John's River, Florida, they are very unusual. Though familiar in the fisheries of that region since 1873, I have only known of the capture of two individuals. Mr. Stearns has obtained one or two specimens in the Gulf of Mexico, and gives an account of the degree of their abundance in those waters. He writes: "They are occasionally caught on the northern shores of the Gulf, and are evidently more common about the mouths of the Mississippi River than elsewhere, since they are taken in this region only in seines, and in shallow water their abundance cannot be correctly determined. The earliest account I have been able to obtain of the capture of Striped Bass in Pensacola Bay is that of Capt. John Washington, of Mystic, Connecticut, who states that in 1850, while seine-fishing from the smack 'Francis Parkes,' he surrounded with his seine a large school of fish, which were quite unmanageable; a few of them were saved, and proved to be large Striped Bass, weighing from fifteen to forty pounds. At long intervals since solitary individuals have been taken at various points on the coast. At New Orleans it is found in the market quite often. An eighteen-pound specimen was sold there in March, 1880."

In Hallock's "Sportsman's Gazetteer" the following statement occurs: "It is constantly seen in rivers of fresh water at great distances from the ocean, even as far up the Mississippi as Saint Louis, and it is common in White River, Arkansas, and in all the rivers of the Southern States."

While there can be no question that straggling individuals of this species have been taken in the Gulf of Mexico, it seems probable that both Mr. Stearns and Mr. Hallock have been mistaken by the resemblance of this species to the Brassy Bass, *Roccus interruptus*, which abounds throughout the Lower Mississippi Valley.

Canadian authorities inform us that, though the Bass still occur along the New Brunswick and Nova Scotia shores of the Gulf, they are much less abundant and of smaller size than formerly. They have been known to ascend the Saint Lawrence as far as Quebec, and Mr. Roosevelt has seen a specimen, a female fish, which was taken in the Niagara River, near Lewiston. The Bass is most abundant in the bays and inlets about Cape Hatteras, in the Chesapeake and Delaware Bay region, and in the protected waters of Long Island and Southern New England. In winter they occur in considerable numbers in the Altamaha River, and are not unusual in the markets of Charleston, South Carolina.

HABITS.—The Striped Bass is not migratory, being found along our coast in winter as well as in summer, and in our markets in every month of the year. Great quantities are taken in winter in the rivers tributary to the Chesapeake, and in the rivers of New Brunswick quantities of them are speared through holes in the ice. During the past four years I have known of their capture in Long Island and Block Island Sounds and in the Merrimac River in December, and in Martha's Vineyard Sound and the lower part of the Hudson River in January. Though they appear to avoid a temperature higher than 65° or 70° they are not sensitive to cold, and there is good evidence that they frequently, when detained throughout the winter in shallow places, enter upon a state of torpidity.

FOOD.—They are very voracious feeders. Entering the rivers, they prey upon small fishes.

They are particularly abundant at the time of the spring runs of the shad and herring, and at this season are particularly plump and well fed, doubtless owing to the ease with which they can obtain food. They also frequent the rocky shores of the bays and sounds at high tide in search of crabs, shrimps, and squids; and they are said to feed upon clams and mussels, which they obtain by delving with their snouts.

REPRODUCTION AND GROWTH.—They spawn in the late spring and early summer, some of them in the rivers, others probably at sea, although this has not been definitely ascertained. The European Bass are said to deposit their spawn near the mouths of rivers in the summer months. From North Carolina to New Jersey the spawning time appears to be in May; in New Brunswick in June. Dr. Blanding, many years ago, estimated the number of eggs at 2,248,000. Their rate of growth is very rapid. Dr. C. C. Abbott, for five successive years, found in the Delaware River young an inch long in the second week in June. About the middle of October these had grown to the length of four and a half inches. The young fish—five to nine inches in length—which are taken in such quantities in the Potomac in February and March, are supposed to be the young of the previous year. Captain Gavitt, of Westerly, Rhode Island, has caught Bass in June that weighed from one-half to one pound, put them into a pond and taken them out in the following October, when they weighed six pounds. The average size of this fish probably does not exceed twenty pounds. In the Potomac, Hudson, and Connecticut Rivers the largest seldom exceed thirty or forty pounds, though in the Potomac fifty-pound fish are not unusual. The Fish Commission has for several years had a standing offer of a reward for a sixty-pound fish from the Potomac, but none has been forthcoming as yet. The largest Striped Bass on record was one weighing one hundred and twelve pounds, taken at Orleans, Massachusetts, in the town cove. Such a fish would be at least six feet in length. A fairly proportioned Bass thirty-six inches long would weigh at least eighteen pounds.

USES.—The Striped Bass is one of the most valuable of our food-fishes, its flesh being firm, finely flavored, and hard enough to bear exposure to the air for some time without injury. It is also the most popular game-fish, next to the salmon. Those in the markets are chiefly obtained in seines and traps set at various points along the coast from the south side of Cape Cod to New Jersey. Great quantities are also taken in shad seines in the spring.[1] They may be readily taken, also, by heaving and hauling in the surf with menhaden bait, the fish being tolled by the use of great quantities of menhaden ground into small bits, and in fresh or brackish water by the use of the artificial fly. At various points on the coast of Southern New England are club-houses supported by wealthy amateurs for the purpose of carrying on these sports.[2]

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[1] Messrs. Christian, Austin, Haight, McKeel, Van Nort Brothers, and about forty others from Peekskill and Verplanck's Point, have about four hundred nets fishing on the ice between Gees Point and Warner's Island, and from the way they are shipping the Striped Bass to New York and Peekskill they must be doing quite a business. On the 14th and 15th instant they shipped about 800 pounds each day, and on the 16th they shipped about 1,200 pounds, and on the 18th they had over 1,000 pounds. They sell them at wholesale for nine and ten cents per pound, and at retail for twelve cents. They use nets about twelve feet square, with two and a quarter inch meshes, to which they attach lines and heavy weights, and sink them about forty feet below the ice. The average weight of the Bass is about one and a half pounds, but a large number have been caught that weigh from twelve to fifteen pounds. They lift their nets at the ebb and flood tides, but are usually caught on the flood tide. The river being clear of ice from this point all the way to New York accounts for their coming from down the river to this place to fish.—*Springfield Republican*, May 24, 1878.

[2] "The Island of Cuttyhunk is about sixteen miles from New Bedford, at the extreme southwesterly boundary of Buzzard's Bay, whose foaming billows wash its northern shore, while the ocean itself beats upon the south, and near Penekese, the island school of Professor Agassiz. The Cuttyhunk Club own about three hundred acres of land, and have the exclusive right to fish on the shores and in the ponds of the island. When the club was first formed they stocked one of the ponds on the island with Black Bass, and these have multiplied so plentifully that they are now caught in large numbers. No fishing was allowed for three years from the time the pond was stocked. Perch and trout are also plenty in ponds on the island. Twenty-six fishing stands have been built at Cuttyhunk, and they

It has already been stated that the Striped Bass are believed to be less abundant in the Gulf of Saint Lawrence than in former years; similar complaints are heard from the Bay of Fundy and from Cape Cod, where the period of diminution is believed to date from the last advent of the Bluefish, about 1850. The bass fishery in Cape Cod Bay was formerly of great importance, but the capture of this fish is now of rare occurrence.[1] The early settlers of New England seem to have been more impressed by the abundance of Bass than by any other circumstance connected with the fisheries, and the early chronicles are full of allusions to their exceeding plenty and excellence. Capt. John Smith saw so many in one river that he declares that he thinks he might have walked across on their backs dry-shod. While there can be no doubt that north of Cape Cod their numbers have decreased, there is no reason to believe that elsewhere on our coast the fisheries have had any special effect upon them. A Hessian officer, writing in 1777, declared that enormous numbers were at that time brought to New York, and the same might be said at the present day. Three fishing gangs at Bridgehampton, New York, took over 8,000 in less than a week, in December, 1874. Capt. Charles Ludlow secured at one set of his seine 1,672 Bass, or about three and a half tons; shortly afterwards a New London fisherman brought in 419 Bass, 185 of which had been caught with a hook in three hours. Near Norfolk, Virginia, 1,500 have been taken with a single set of the seine. A few years ago, it is stated on credible authority, that 600 were once taken, the average weight of which was eighty pounds. In the first half of June, 1879, one fisherman near Fire Island, New York, caught and sent to New York the following quantities of Bass:

	Pounds.
June 2	1,222
June 4	1,137
June 5	913
June 6	1,521
June 8	1,298
June 9	1,255
June 14	1,258
June 18	1,560
Total	10,164

extend completely round the island. These stands are built upon prominent rocks, and are supported above the breakers by iron rods. Foot bridges, supported in the same way, are built from the shore to the stands. The stands are all named or numbered, and are drawn for every night by the members of the club. A member drawing a stand can fish from it the next day, or it can be used by any one else by his permission. The stands bear such names as 'Nashawena Point,' 'Canepitset,' 'Old Water Line,' 'Cove Point,' 'Little Bass,' 'Big Bass,' and 'Gulf Rocks.' The stands are all removed after the season is over, to be put up again the next year. 'Central Park' seats have this season been placed on the bluffs round the island at convenient points, from which to watch the fishing at each stand, so that members who are not lucky enough to secure favorite stands can sit with ease and enjoy the sport of their fellow-members. The favorite fishing is for Striped Bass, and, during the best of the season, the sport is commenced as early as three o'clock in the morning. A record is kept at the club house of the daily catch, by whom caught, where taken, on what station, the number of fish, weight, and date. Some members of the Cuttyhunk Club also belong to the West Island Club, which controls only five acres of land. The West Island Club is limited to thirty members, with an admission fee of $1,000." (Correspondent.)

[1] The harbor and contiguous waters were, in early times, as is well known, richly supplied with great varieties of fish. Bass were abundant many years, so that generally three hundred quintals were ready for market in a single season; *few*, comparatively, of these are now taken. We say *few* in comparison with former days. They are still taken in goodly numbers, and the way of bass-fishing at Race Point affords a finely athletic exercise for chest and limbs. The fisherman stands on the beach and throws out the line with sinker attached as far as strength will permit, and then hauls in, dragging a bouncing fish, if the throw be a good one.—History of Cape Cod (Freeman), ii, 1862, p. 623.

Three hundred Bass, of good size, were taken at one haul with a seine on Yarmouth Flats on Tuesday last. These fish are taken in abundance in our harbor at this season of the year. Many of them are packed in ice and sent to the Boston market, where they bring a good price. "Going a-bassing," as it is termed, is both a pleasant and profitable amusement.—*Barnstable Journal*, July 30, 1829.

Capt. Sam. T. Soper, Provincetown, took seven hundred Bass last Saturday. Fish were seined. Mr. Stephen A. Mayor also caught three hundred Bluefish off the harbor one day last week at one haul.—*Barnstable Patriot*, October 19, 1858.

Wood, writing in 1634, remarked: "The Bass continue at Lynn from the middle of April to Michaelmas" (September 29).

Allen Look, of Tisbury, Massachusetts, testified before the fishery committee of the Massachusetts legislature, in 1870, that in 1845 he caught twenty-seven tons, or about 17,000 Striped Bass, in Tisbury Great Pond, and that the largest catch within the pond from 1865 to 1870 was one hundred, taken in December, 1869.[1]

The following extract from a Newport (Rhode Island) paper for 1861 shows how abundant these fish have been in past years in Narragansett Bay:

"As an evidence that fish are not scarce in our waters, the recent haul of Bass by hook and line is evidence. Within a week the market has been more than supplied, as the following will show:

"Purchased by Samuel Albro: Of Nason & Tenant, 1,339 pounds; William James, 960 pounds; W. A. Munroe, 429 pounds; Dunwell & Gladding, 1,500 pounds; James Hazard, 357 pounds.

"Purchased by Carry & Co.: Of George Crabb, 950 pounds; John Heath, 130 pounds; James Read, 300 pounds; Edward Smith, 60 pounds; G. Dunwell, 50 pounds.

"Henry Gladding & Co. shipped to New York 1,100 pounds. Making a total of 7,175 pounds for one week, and these were all taken from the rocks at the south end of the city."

The Rock-fish has been propagated artificially by the United States Fish Commission, the first experiment having been made by Mr. Holton in 1873, supplemented by more satisfactory operations in 1879, under the direction of Major Ferguson, when about 400,000 eggs were hatched out and turned loose in Salmon Creek, North Carolina. The species was introduced into California some years ago, and Jordan reported in 1880 that several specimens had been captured along the coast.

143. THE WHITE BASS—ROCCUS CHRYSOPS (Raf.) Gill.

This species is generally known by the name of "White Bass"; occasionally as "Striped Bass." Its greatest abundance is in the Great Lake region, although it has a wide distribution in the Ohio and upper tributaries of the Mississippi, and is found in many streams farther south. It frequents chiefly the lakes and ponds and the deeper parts of the rivers. It feeds upon minnows and the like, usually taking the hook readily, and is considered gamy by the angler. As a food-fish it ranks high, being little inferior to the Black Bass. Its usual weight is from one to three pounds. The White Bass is said to be an excellent fish for cultivation in artificial ponds. Like most of its relatives, this species spawns in late spring.

"It is frequently taken in the Ohio River," writes Jordan, "and frequents chiefly deep or still waters, seldom ascending small streams. It is said to thrive well in ponds."

This is doubtless the Silver Bass of Canada (*le Silver Bass du Canada*), the details of whose introduction into France, and successful propagation by M. Carbonnier, from 1877 to 1879, are recorded by that experimenter in the "Bulletin of the Society of Acclimation for 1881."[2]

The following notes upon the abundance of the White Bass, *Roccus chrysops*, in the Great Lakes and bays adjacent have been made by Mr. Kumlien:

Two instances only of the presence of this species at and in the vicinity of the Apostle Islands are known to Mr. Bantin. Some of the other fishing points of that region are as follows: Sand Island, York and Rock Islands, Magdalen Island, Chequamegan Point, and Siscourt and Fry Bays.

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[1] Four hundred Bass were taken at a single haul in Tisbury Great Pond, Martha's Vineyard, on one day last week, and shipped to New York.—*Gloucester Telegraph, November* 23, 1870.

A cargo of four hundred and nineteen Striped Bass, one of which weighed more than fifty pounds, was brought into New London by an old fisherman a few days since. One hundred and eighty-five of them were caught with a hook and line in three hours.—*New York Evening Post, December* 1, 1874.

[2] *Bulletin Mensuel de la Société d'Acclimation, viii, No. 2, p. 10.*

In all other parts of Lake Superior this fish is not recorded as being known. In the fishing grounds at the north end of Green Bay, White Bass are known only as stragglers. Farther down the bay, about Cedar River, they are rare, but are more common on the shoals between Menomonee and Peshtego. They are taken principally in September, are important, and command a ready sale. They do not frequent deep water. Between Peshtego and Longtail Point, including the fishing points at Maple Bend, Pensaukee, Gail's Point, and Oconto Bay, White Bass are rather common, and important during August and September; at other times they are seldom taken. They are caught in the pound-nets, are much sought for early in autumn, and are shipped principally to Saint Louis.

The White Bass is a beautiful, clean-looking fish, presenting a fine appearance and bearing shipment well. At Green Bay City, the southern extremity of Green Bay, this species is abundant. On the eastern shore of Green Bay, bordering upon the counties of Door and Kewaunee, and as far north as Saint Martin's Island, they are taken in small quantities in autumn, but are not abundant enough to be shipped.

At Jacksonport, on the western shore of Lake Michigan, a few White Bass are taken in autumn. At Two Rivers they are not rare in September. A couple of dozen may be found among one or two thousand pounds of fish, and then may be entirely absent for a long time. At Manitowoc they are often taken in some numbers in September, when large runs sometimes occur, and then none are taken, perhaps, for two or three years. During the last three years very few have been taken. Mr. Patterson, of that district, thinks the bass family is increasing in the vicinity of Manitowoc.

At Milwaukee White Bass used to be so abundant that they were largely caught on hooks off the piers, but now only a few are taken in the pound-nets. At the south end of Lake Michigan White Bass come in great numbers in April and September, entering the river, but not being taken to any extent in the pound-nets. The principal fisheries of that region are those of New Buffalo and Michigan City. Here they run small, and are of no commercial importance.

White Bass are abundant on the eastern shore of Lake Michigan, between New Buffalo and Saugatuck, making their first appearance during the warm days of May or June. At this time they strike in from the lake in great numbers. They remain about the mouth of Saint Joseph's River till September, and sometimes October, and even ascend the river several miles. After September they work out into the lake again. They associate with the Black Bass in schools. They are not sufficiently abundant, however, to be of any commercial importance, as no seining is done; if that kind of fishing were carried on, almost any number might be taken. The White Bass is considered one of the "game" fish. Specimens have been taken weighing over three pounds. When coming in from the lake to the river they are very light in color, but become darker during their stay. Mr. Hatch has put specimens in his fish ponds, the bottom of which is of black muck, and these have become black on the back.

Along the eastern shore of Lake Michigan, from Allegan County to Leelenaw County, they are reported as quite common, especially about Manistee, Ludington, and Point au Sable, but as having been less abundant this year (1880) than usual. At Grand Haven they are plentiful and of a large size. About and in Grand Traverse Bay, Little Traverse Bay, and Fox Islands, they must be of great rarity, the first instance of their occurrence known to Miller, in this region, having been in Little Traverse Bay during the summer of 1880. Off the shores of Emmet, Cheboygan, and Presque Isle Counties, Michigan, which coast line includes the northeast portion of Lake Michigan, the Straits of Mackinaw, and the northwest portion of Lake Huron, White Bass are by all pronounced rare. Captain Coats reports the capture of three in 1880, and thinks they are

decreasing in abundance; and Captain Dingman says he has not taken half a dozen in fifteen years' fishing. Some report them as more plentiful about river mouths and bayous. At Alpena, Thunder Bay, Mr. Case knows of but four or five White Bass having been caught.

On the fishing grounds of Saginaw Bay, including also those of Charity Islands, a very few White Bass are occasionally taken in May and the first part of June. They were never abundant in this region. South of Saginaw Bay, on the western shore of Lake Huron as far as Port Huron, White Bass are not at all abundant, and are now far less abundant than formerly. Those now taken are captured principally in the Saint Clair River, though they occur, sparingly, however, on both the American and Canadian shores of the lake between Point aux Barques and Port Huron. From Toledo to the mouth of the Detroit River, Lake Erie, they are now rather rare, so much so as to render them of no commercial value. Formerly they were plenty. In Lake Erie, about the mouth of Maumee Bay, White Bass are not so abundant, as they once were. They now occur principally in the bay, ascending the Maumee River until prevented by obstructions. At present they are not taken in sufficient numbers to be of any commercial value. No reason can be assigned for their sudden decrease in this locality. In 1865 a catch of from ten to thirty tons was an event of no rare occurrence, and now it is seldom that more than one to two hundred pounds are taken at a lift.

On the fishing grounds of Ottawa City, Toussaint, and Locust Point, White Bass are now quite rare and of no importance. Formerly they were very abundant. On the reefs off Port Clinton they are still taken in some quantities with the Black Bass. On these reefs no driving is possible, but the leads are buoyed up across the reefs, and the heart and pot stakes are set in the mud off the rocks.

In the vicinity of the Huron fisheries and Sandusky Bay, White Bass have decreased very much within a few years, and in fact are now rather scarce. At present, in early fall and late spring a few are taken; some years, almost none. They occur at all the fisheries, without any apparent choice of locality. They are a good market fish, but do not keep well during warm weather; are sold fresh, if possible, but a good many are salted. Rank higher than the herring. This species is now almost extinct on the same grounds where they were once fairly swarming. The following is said to be true, and many prominent men of Sandusky offer to corroborate it, unlikely as it sounds: In May, 1855, off Marble Head light-house, with a twenty-two-foot net, sixty rods leader and old-fashioned funnel, were taken out, at one lift, forty tons of White Bass! This was at that time the only pound between Huron and Marble Head. On the same ground, from March 28 to May 4, twelve hundred dollars' worth were taken in one net. For many years they were considered the most abundant fish in the vicinity of Sandusky. It is also thought that they were the most destructive of all fish to the white-fish. Mr. Anthony says he saw in 1848, on the Ottawa beach, the white-fish eggs driven up on the shore inches deep after a heavy gale, and it was well known to the fishermen that in spring the White Bass swarmed on the spawning grounds of the white-fish for the purpose of devouring the young fish. No one seems to have any theory about their sudden and mysterious decrease. It is also remarked that simultaneous with the disappearance of the White Bass the herring and blue pike increased. The fishermen consider them so destructive to other fish that their decrease is welcomed with satisfaction.

The white-bass fishery was very important at Huron, Ohio, some years ago, but the fish have decreased, and now the catch is almost nominal. At Vermillion, Ohio, White Bass are not very abundant; they are caught principally early in spring and during the first few days of autumn fishing. They average less than one pound in weight. Formerly they were more abundant and of a larger size. A few are salted. Between the mouth of Black River and Brownhelm Bay

White Bass are taken in considerable numbers in the small pounds, close inshore; most of the pound-nets are set in water too deep for this fish. Until two years ago they were abundant, and after that time (1878) few were taken until the fall of 1879, when they again appeared in considerable numbers. The average weight in these localities is about one pound. They are graded as "soft" fish, but have an excellent sale, and if sold separately bring a higher price than soft fish. They are said to spawn close inshore during the latter days of May. Between Black River and Vermillion there are now only three nets set in water shallow enough to take them in abundance.

At the Cleveland and Dover Bay fisheries White Bass are quite plentiful, much more so than the Black Bass. There is a great difference in the average size in different years, although in those years when they are small they are none the less numerous. The "runs" occur early in spring. They are classed as "soft" fish. At Conneaut and Ashtabula they are considered a rare fish. They do not frequent deep water, and consequently are not taken in the gill-nets. On the Lake Erie shore of Lake County, Ohio, White Bass are quite common. About five tons were caught at Painesville in the autumn of 1879. They are generally large fish, and are caught at all seasons during calm weather, but strike for deep water during wind storms. Off Erie, Pennsylvania, Mr. Olds says he has known of the occurrence of one very large school, but they are generally considered quite rare.

At the principal points on the New York shore of Lake Ontario the occurrence of White Bass is thus noted: At Oswego they are not abundant. They occur principally in the lake, but are also found in the river. At Port Ontario only one or two specimens have been known. At Cape Vincent they are rarely caught, and are of no commercial importance. Those consumed are brought, for the most part, from Canada. At Chaumont a very few are occasionally caught; the fish here are of no importance. At Sacket's Harbor very few occur. They have slightly increased, rather than the reverse, in abundance.

144. THE YELLOW BASS—ROCCUS INTERRUPTUS.

This species is, so far as known to us, always known as the Yellow Bass. It is found throughout the lower course of the Mississippi, ascending the tributaries which are deep and sluggish, but not running past rapids or into the upper courses of the rivers. Jordan states that its range extends up the Ohio to the mouth of the Wabash or beyond, though it does not seem to be common anywhere except in the Lower Mississippi. It probably enters salt water, but of that we have no certain information. It is taken in considerable numbers in the regions where found, and is graded with the White Bass, which it much resembles in size and color. Little is known in regard to its habits. The criterion by which it may be distinguished from the White Bass is the low membrane connecting the two dorsal fins. Its color is yellow, not silvery, and the black stripes are very prominent.

145. THE WHITE PERCH—ROCCUS AMERICANUS.

Next in importance to the Striped Bass is the so-called White Perch, *Roccus americanus*. This fish occurs in brackish water in the mouths of rivers, and even, in many instances, in fresh-water ponds, where it had become land-locked, and all along the coast from Georgetown, South Carolina, to Nova Scotia. Dr. Yarrow states that it abounds in the Tar and Neuse Rivers, North Carolina. In the Chesapeake and tributary streams it is exceedingly abundant. It also abounds in the lakes and streams of the Saint John River, New Brunswick, and in the vicinity of Halifax, Nova Scotia. It has been claimed by certain observers in Florida that White Perch were formerly abundant in that region, and the market-men of New Orleans state that they were common in Lake

Pontchartrain until the "Bonnet Carré crevasse" changed the water from salt to fresh. Mr. Stearns, having investigated the subject, is of the opinion that they are mistaken.[1] The habits of this fish have been but little observed; in fact, it has been the custom of nearly all writers on our fishes to speak slightingly of it. It found an earnest advocate in Mr. Thaddeus Norris, who, after protesting strenuously against the statement of various writers that it is rarely brought to market for food, that it is only fit for chowder, that it is not of sufficient importance to merit particular notice, and so on, goes on to state, what is undoubtedly true, that in season the White Perch is *the* pan-fish, excelled by none of the Philadelphia, Baltimore, Washington, Norfolk, and Richmond markets; and he might have added, had he been writing at the present time, of the New York market also, for there is, probably, no fish of its size which is more universally popular throughout the Eastern States than the White Perch. In a single paragraph Mr. Norris, who, though he made no professions of scientific skill, has been one of our best observers of fishes, has given almost the only reliable information which has ever been collected regarding this species. "Its most natural habitat is in fresh tidal rivers, where it is found on flat clay and muddy bottoms, and in shallow water. It is frequently found far above the terminus of the tide, and is often more abundant in fresh than in brackish water in the season of the year when sought for by anglers. This fish, when found in salt-water creeks, is darker in color, but there is no specific difference. The White Perch is a congener of the magnificent Rock-fish, and is frequently found feeding in the same place and in his company. Its average length is eight or nine inches; it is not often more than twelve, though in rare instances it is found fourteen inches long.

"White Perch hibernate in the deep waters of our bays, and ascend the fresh tidal rivers soon after the ice and snow-water have run off. They feed greedily on the spawn of other fish, particularly that of the shad; on insects, crabs, minnows, and on the migratory schools of young eels which are found in the months of April and May in great numbers at any rapid or dam obstructing the upward flow of the tide. Perch usually spawn in May and then resort to deeper waters to recuperate, and all summer long are found by the angler ever swimming around the deep-sunk pier or the timbers of the rickety old bridge, snapping at shrimps or chasing the minnows; at flood tide high up amongst the water-lilies, and never refusing a bait, if of the right sort and properly presented."[2]

Dr. C. C. Abbott has added some important observations. He found female fish heavy with apparently ripe ova as late as June 10. The largest specimens of White Perch taken in the Delaware weighed, respectively, one pound nine ounces, one pound thirteen ounces, and two pounds one ounce. These were caught in a shad net in May, 1865, at the fishery opposite Trenton. The average adult fish may be said to measure eight inches and weigh from seven to nine ounces. He continues: "I believe, for reasons to be given, that the growth of the young is very rapid, and that the August Perch are young hatched late in the preceding May and April; in June these August Perch measuring about two and a half to three inches in length. . . . I should judge that spawning occurred between May 10 and June 10, usually nearer the former than the latter date. This is based on the fact of having gathered very young fish, the age of which I *guessed* from the general condition and amount of development of the specimens. After the middle of June the White Perch are found in localities widely different; even waters with a dense growth of lily and river weed are found to contain them in apparent health and vigor—spots where the Rock-fish could not live a day. Still later in the summer, as the young Perch become quite strong and

[1] Certainly the Bonnet Carré crevasse never drove the White Perch out of Lake Pontchartrain. That lake now contains small Sharks, *Trygon*, *Pogonias Bairdiella*, and hosts of fish of salt-water habits, with less liking for fresh water than the White Perch.—D. S. JORDAN.

[2] American Angler's Book, p. 90.

of some size, the river, although in and above tide-water, fairly teems with them. At this season they go in schools, sometimes of large size. I have known of twelve, fifteen, and twenty dozen August Perch being taken with a line in as short a time as from three to five hours. Fishing in this way a line with half a dozen hooks is used, and worms, sturgeon spawn, or live minnows are used as bait. These schools of small Perch I supposed to be broods of the preceding May, and that they kept together until late in November. They pass down to the salt water and there separate. Larger adult fish are not as restless as these smaller ones, and are found in deeper water, and usually in the tide-waters. In their feeding habits the White Perch agree very closely with the rock-fish. In all their habits, in fact, the two fish are much alike, and in the Delaware they are always associated, the most noticeable difference in their habits being the ability of the Perch to remain and thrive in warmer waters than the Rock-fish is ever found frequenting."[1]

So much has been said by the standard authorities in past years regarding the inferior quality of this fish as an article of food that it seems worth while to recur to this point, and to state that at the present time there is no fish found in the markets of our seaboard towns which is more generally a favorite for frying, or, as the phrase goes, as a pan-fish, than the White Perch.

146. THE BLUEFISH FAMILY—POMATOMIDÆ.

THE BLUEFISH.—POMATOMUS SALTATRIX.

NAMES.—This fish, which on the coast of New England and the Middle States is called the Bluefish, is also known in Rhode Island as the "Horse Mackerel"; south of Cape Hatteras as the "Skipjack"; in North Carolina, Virginia, and Maryland it is said to be called the "Green-fish." Young Bluefish are in some parts of New England called "Snapping Mackerel" or "Snappers"; about New Bedford "Blue Snappers"; to distinguish them from the Sea Bass they are sometimes spoken of as the "Bluefish." About New York they are called "Skip Mackerel," and higher up the Hudson River "White-fish." In the Gulf of Mexico the name "Bluefish" is in general use.

DISTRIBUTION.—This species is widely distributed—in the Malay Archipelago, Australia, at the Cape of Good Hope, at Natal and about Madagascar; in the Mediterranean, where it is a well-known and highly-prized food-fish in the markets of Algiers, though rare on the Italian side. It has been seen at Malta, at Alexandria and on the coast of Syria, and about the Canaries. It has never been seen on the Atlantic coast of Europe, and, strangely enough, never in the waters of the Bermudas or any of the Western Islands. On our coast it ranges from Central Brazil and the Guianas through the Gulf of Mexico and north to Nova Scotia, though never seen in the Bay of Fundy. From Cape Florida to Penobscot Bay, Bluefish are abundant at all seasons when the temperature of the water is propitious. It is not yet known what limits of temperature are the most favorable to their welfare, but it would appear, from the study of the dates of their appearance during a period of years in connection with the ocean temperature, that they prefer to avoid water which is much colder than 40°. It is possible that the presence of their favorite food, the menhaden, has as much influence upon their movements as water temperature. It is certain that few Bluefish are found on our Middle and Southern coast when the menhaden are absent; on the other hand, the Bluefish do not venture in great numbers into the Gulf of Maine at the time when menhaden are schooling and are at their greatest abundance. Their favorite summer haunts are in the partially protected waters of the Middle States, from May to October, with an average temperature of 60° to 75°. The menhaden, or certain schools of them, affect a cooler climate and thrive in the waters of Western and Central Maine in the months when the harbor temperatures are little above 50° and 55°, and that of the ocean considerably lower.

Professor Baird has published in the First Report of the United States Fish Commission an

[1] Report U. S. Fish Commis., part iv, 1878, p. 375.

exhaustive account of the habits of the Bluefish which will be quoted from freely in this chapter. The presence of quotation marks will be sufficient to indicate the source of the paragraphs taken from his essay without further reference to his name.

"MOVEMENTS AND MIGRATIONS.—The Bluefish is pre-eminently a pelagic or wandering fish, and like many others, especially of the *Scombridæ*, is apparently capricious in its movements, varying in numbers at particular localities with the year, and sometimes disappearing from certain regions for a large fraction of a century, again to return as before. The cause of this variation it is impossible to explain, being due in some instances, probably, to the disappearance of its favorite food in consequence of its own voracity, or for other undetermined reasons.

"*They occur during the summer throughout the entire range indicated for the United States*, but are much larger in size and in greatest abundance from the coast of New Jersey northward. From New Jersey southward, in the season mentioned, with the exception of an occasional wandering school, they are generally only about eight to twelve inches in length, representing, *therefore, in all probability, individuals of the second year's growth.*

"They appear to have a regular migration along our coast, presenting themselves later and later in the spring, the farther they are found to the north, and disappearing in the inverse order from the same regions in the autumn. First noticed on the Carolina coast as early as March and April, immense schools of them, bound eastward, are seen off the coast of the Middle States from the middle of May to the middle of June,[1] and in October similar bodies, perhaps embracing fewer individuals, pass to the southward. It is possible, however, that in the autumn some schools *move well out to sea, and are, therefore, less likely to be observed. They leave the northern coast* about the middle of October, and about the middle of November appear in vast numbers off the coast of North Carolina, where, from Nag's Head, in Currituck County, to Cape Lookout, there is a very extensive fishery prosecuted, which furnishes Bluefish for the Northern markets. It is *estimated that at least one hundred and fifty crews are engaged in this fall fishing*, which lasts generally until late in December. At this time individuals may be taken weighing fifteen to eighteen pounds, although their average size is about ten.

"Their occurrence in autumn off the coast of North Carolina is preceded and first indicated by the vast schools of menhaden, which they follow in, several miles from the sea, and by the usual accompaniment of flocks of gulls attending them to take a share in the feast. Of the particular mode of fishing in this neighborhood we shall take occasion to speak hereafter.

"According to Dr. Yarrow, the Bluefish are first seen in spring on the North Carolina coast (the smaller ones first) in March or April, when, however, they are much less in size than the specimens referred to as occurring in the fall. The precise time of their appearance at most of the points farther north has not yet been ascertained. Whether they actually migrate from south to north, and *vice versa*, or merely come in from the outer seas in regular order, as is believed to be the case with the shad, etc., has not been settled, although the former supposition appears the more probable. They reach the New Jersey coast some time in the early part of May, and usually appear at Newport and in Vineyard Sound (the time varying with the season) from the middle of May to the first week in June. They are expected at Edgartown from the 25th to the 30th of May; but I am informed that, on their first arrival, they feed at the bottom, and sometimes for a while are not seen at the surface at all, seldom being taken with the hook, but caught in large numbers in pounds and with the gill-net, usually along the lower edge of the net. According to Dr. Yarrow,

[1] *In the Chesapeake, according to Dr. Wilkins, at Hunger's Wharf, Virginia, the Taylor is one of the most abundant fish, as many as four thousand being caught at one lift of the pound. The average size is about three pounds. They come about the first of June and leave early in October.*

they are not taken with the hook about Beaufort until about the 1st of July. They do not bite, however, in Vineyard Sound until from the 10th to the 15th of June, when they appear on the surface, and are caught in large numbers in the usual manner."

In the first week of May, 1878, about a thousand Bluefish, weighing four pounds each, were caught off Long Island at Canarsie and West Hampton. This is about two months earlier than is usual for them to be taken in any considerable numbers.

"PERIODICITY.—Great interest attaches to this fish in consequence of the changes in its abundance, and even its actual occurrence on our coast, within the historic period. The precise nature and extent of the variation has not been established, nor whether it extended along the entire coast or not. Its earliest mention for our waters is in the work of Josselyn ('New England Rarities Displayed,' 1672), where, on page 96, he mentions the 'blew-fish, or horse,' as being common in New England (his residence was on the New Hampshire coast, or near by in Maine,) and 'esteemed the best of sort of fish next to rock-cod.' He says: 'It is usually as big as the Salmon, and a better meat by far.' He also, on page 24, catalogues two kinds of 'Blew-fish' or 'Houndfish'; the 'Speckeled Houndfish' and the 'Blew Houndfish, called Horsefish.' There appears to be no species to which this reference could apply excepting the subject of our present article, this being the opinion of Mr. J. Hammond Trumbull, who has devoted much research to determining the modern equivalents of ancient Indian names of animals, and to whom I am indebted for the hint. Mr. Trumbull also remarks that in a manuscript vocabulary obtained by President Stiles, in 1762, from a Pequod Indian at Groton, Connecticut, there is mentioned the 'Aquaundunt or Blue-fish,' clearly the same as what now bears that name, which shows that this fish was found in Fisher's Island Sound in 1762.

"Again, according to Zaccheus Macy,[1] the Bluefish were very abundant about Nantucket from the first settlement of the English on the island, in 1659, to 1763, and were taken in immense numbers from the 1st of June to the middle of September. They all disappeared, however, in 1764, a period of great mortality among the Indians of that island. It has been suggested that the disease which attacked the Indians may have been in consequence of an epidemic in the fish upon which they fed, or else that it invaded both fish and Indians simultaneously, resulting in almost their entire extermination.[2]

"According to Dr. Mitchill, this fish was entirely unknown about New York prior to 1810; but they began to be taken in small numbers about the wharves in 1817, and were abundant in 1825. Immense numbers were caught at the Highlands in 1841. The doctor remarks, as has been done repeatedly by others, that as the Bluefish increased, the squeteague or weak-fish diminished in about the same ratio.

"According to Mr. Smith, of Newport (Rhode Island), his father used to catch Bluefish some time about the year 1800, when they were very abundant and of large size, weighing from sixteen to eighteen pounds.

"Capt. Francis Pease, of Edgartown, also testified that his father spoke of large Bluefish at the end of the preceding century, some of them weighing forty pounds. This leaves an interval between 1764 and toward the end of the century in which no mention is made of the Bluefish, and which may probably indicate its absence, as during that time there were many works published

[1] Collections Massachusetts Historical Society for 1794, iii, 1810.

[2] "From the first coming of the English to Nantucket (1659) a large fal-fish, called the blue-fish, thirty of which would fill a barrel, was caught in great plenty all round the island from the 1st of the sixth month (June) till the middle of the ninth month (September). But it is remarkable that in the year 1764 . . . they all disappeared, and that none have ever been taken since. This has been a great loss to us."—*Ibid.*, 1792, p. 159. Zaccheus Macy's Account of Nantucket."

relating to the local history and domestic economy of New England, and which would doubtless have taken note of so conspicuous a fish had it been present.

"Whether they existed uninterruptedly during the century intervening between Josselyn's time, 1672 (or even 1659, according to Macy), and 1764, I am at present unable to say. According to Captain Pease, they were known about Edgartown at the end of the last century.[1] As already stated, Dr. Mitchill speaks of their first making their appearance about New York in 1810. They are noted as having been seen in Vineyard Sound again as early as 1820. It would therefore appear that they were in such small numbers about New York in 1810 that the young only were noticed flocking about the wharves, and that in ten years they were observed as far east as Nantucket, where the specimens seen from 1824 to 1826 were very small, not over four inches. The next year they measured seven, and the third year ten inches, according to the testimony of one witness, although this does not represent, in all probability, the rate of growth.

"According to Captain Burgess, of Monument, Massachusetts, they were caught about Nantucket in 1825, and were very abundant in 1830. Dr. Storer states the first Bluefish recorded as having been noticed in the present century north of Cape Cod was captured on the 25th of October, 1837. Captain Atwood remarks that in 1838 he saw Bluefish for the first time about Provincetown. These were very small, the largest weighing only two pounds. In a few years, however, they became larger and more numerous, and finally increased to such an extent as to exercise a very marked influence upon the fisheries. According to the captain (Proceedings of Boston Society of Natural History, 1863, p. 189), they arrive in Massachusetts Bay in a body, coming at once, so as to almost fill the harbor at Provincetown. In one year they came in on the 22d of June, and although the day before eight thousand mackerel were taken, the day after not one was seen or captured. He says that they leave about the last of September, with the first cold northeasterly storm, although stragglers are taken as late as December at Provincetown.

"According to Messrs. Marchant and Peter Sinclair, of Gloucester (October, 1872), Bluefish made their first appearance in numbers about Cape Ann twenty-five years ago, coming in great force and driving out all other fish. They are now much scarcer than twenty years ago; about the same as tautog; some seasons scarcely noticed.

"Mr. J. C. Parker, an aged gentleman of Falmouth, says the first Bluefish seen at Wood's Holl in this century was taken in July, 1831; but his father informed him that they were abundant in the preceding century, about 1780 or 1790, at which time they disappeared; and that when the Bluefish left, the scup first made their appearance. They are also noted as having shown themselves at the head of Buzzard's Bay in 1830 and 1831, and, although numerous, were of small size, measuring about a foot in length.

"To sum up the evidence, therefore, in regard to the periodical appearance of the Bluefish, we find notice of its occurrence in 1672, or even 1659, and up to 1764. How long it existed in the waters prior to that date cannot now be determined. The oral testimony of Mr. Parker refers to its occurrence at Wood's Holl in 1780 or 1790; and it is mentioned by Mr. Smith as being at Newport in 1800, and at Edgartown, Massachusetts, about the same time by Captain Pease. Mitchill testifies to its occurrence in New York, of very small size, in 1810; and it is recorded as existing again at Nantucket in 1820, and about Wood's Holl and Buzzard's Bay in 1830 to 1831; and a little later at Hyannis. In 1830 it had become abundant about Nantucket, and in the fall

[1] President Dwight bears witness to the fact that Bluefish were abundant in the Narragansett Bay region as late as 1780. "The Horse Mackerel formerly frequented this coast in immense numbers, and in the season were constantly to be found in the market. But about the close of the Revolutionary war they forsook our waters and have not made their appearance since. They were esteemed a great delicacy, and are the largest of the mackerel species.—Note on Fishes of Newport, Rhode Island. Dwight's Travels, iii, 1822, p. 50.

of 1837 it was first noticed in Massachusetts Bay; and then year by year it became more and more numerous, until now it is very abundant. Several accounts agree in reference to the very large size (even to forty or fifty pounds) of those taken in the last century.

"Further research into ancient records may tend to throw more light on the early history of the Bluefish, and even materially to change the conclusions already reached. It will be observed that the references to its occurrence, from 1780 to 1800, are on the testimony of aged persons who have heard their fathers speak of it, although I find no printed records anywhere in reference to it between 1764 and 1810. The rate of progression to the north of Cape Cod I have at present no means of indicating, although they probably gradually extended farther and farther north, and may possibly occur much farther east than we have any mention of at present.

"During the present century the maximum of abundance of these fish off the middle coast of the United States appears to have been reached from 1850 to 1860. The testimony elicited from various parties, as well as from printed records, indicates a decrease since that period much greater in some localities than others. About New York they are said to have been unusually plenty in the summer of 1871, but farther East the diminution which had been observed in previous years appeared to continue."

Since the writing of the above, in 1871, there has been no special change in the abundance of Bluefish. They are quite sufficient in number to supply the demand for them and to make great inroads upon the other fishes, some of which, like the menhaden and mackerel, would perhaps, if undisturbed by the Bluefish, be more valuable than they are at present. They have now been with us for fifty years. Their numbers are subject to periodical variation, of the cause of which we are ignorant. It is to be regretted that there are no records of it in the South Atlantic States. If such existed, we might, perhaps, learn from them that the Bluefish remained in those waters while absent from the northern coasts. Only one statement is to be found which covers this period, although Lawson, in his "History of North Carolina," published in 1709, and Catesby, in his "Natural History of the Carolinas," published in 1743, refer to its presence. In "Bartram's Travels," published in 1791, "Skipjack" is mentioned as one of the most abundant fish at the mouth of the Saint John's River. When Bluefish again became abundant their presence was first noticed at the South, and they seem to have made their inroads from that direction. The Bluefish was unknown to Schoepf, if we may judge from his work on the "Fisheries of New York," published in 1787. Dr. Mitchill recorded their frequent capture about New York in 1814, though before 1810 they are said to be unknown in that locality. In 1825 they were abundant here, and in 1841 immense numbers were captured in the Vineyard Sound, and about Nantucket they were on the increase from 1820 to 1830. It is certain that they had not reappeared in 1822 in Narragansett Bay, for in "Bertram's Travels" it is stated that, though formerly abundant, they had not been seen in that region since the time of the Revolution.

The first one which was noticed north of Cape Cod was captured in October, 1837, while we have no record of their appearance about Cape Ann before 1847.

FOOD AND VORACITY.—The Bluefish is a carnivorous animal of the most pronounced type, feeding solely upon other fish. In this connection it cannot be out of place to reprint Professor Baird's remarks upon this subject, which have been so often quoted during the past ten years:

"There is no parallel in point of destructiveness to the Bluefish among the marine species on our coast, whatever may be the case among some of the carnivorous fish of the South American waters. The Bluefish has been well likened to an animated chopping-machine, the business of which is to cut to pieces and otherwise destroy as many fish as possible in a given space of time. All writers are unanimous in regard to the destructiveness of the Bluefish. Going in large schools,

in pursuit of fish not much inferior to themselves in size, they move along like a pack of hungry wolves, destroying everything before them. Their trail is marked by fragments of fish and by the stain of blood in the sea, as, where the fish is too large to be swallowed entire, the hinder portion will be bitten off and the anterior part allowed to float away or sink. It is even maintained, with great earnestness that such is the gluttony of the fish, that when the stomach becomes full the contents are disgorged and then again filled. It is certain that it kills many more fish than it requires for its own support.

"The youngest fish, equally with the older, perform this function of destruction, and although they occasionally devour crabs, worms, etc., the bulk of their sustenance throughout the greater part of the year is derived from other fish. Nothing is more common than to find a small Bluefish of six or eight inches in length under a school of minnows making continual dashes and captures among them. The stomachs of the Bluefish of all sizes, with rare exceptions, are found loaded with the other fish, sometimes to the number of thirty or forty, either entire or in fragments.

"As already referred to, it must also be borne in mind that it is not merely the small fry that are thus devoured, and which it is expected will fall a prey to other animals, but that the food of the Bluefish consists very largely of individuals which have already passed a large percentage of the chances against their attaining maturity, many of them, indeed, having arrived at the period of spawning. To make the case more clear, let us realize for a moment the number of Bluefish that exist on our coast in the summer season. As far as I can ascertain by the statistics obtained at the fishing stations on the New England coast, as also from the records of the New York markets, kindly furnished by Middleton & Carman, of the Fulton Market, the capture of Bluefish, from New Jersey to Monomoy, during the season, amounts to not less than one million individuals, averaging five or six pounds each. Those, however, who have seen the Bluefish in his native waters, and realized the immense number there existing, will be quite willing to admit that probably not one fish in a thousand is ever taken by man. If, therefore, we have an actual capture of one million, we may allow one thousand millions as occurring in the extent of our coasts referred to, even neglecting the smaller ones, which, perhaps, should also be taken into the account.

"An allowance of ten fish per day to each Bluefish is not excessive, according to the testimony elicited from the fishermen and substantiated by the stomachs of those examined; this gives ten thousand millions of fish destroyed per day. And as the period of the stay of the Bluefish on the New England coast is at least one hundred and twenty days, we have in round numbers twelve hundred million millions of fish devoured in the course of a season. Again, if each Bluefish, averaging five pounds, devours or destroys even half its own weight of other fish per day (and I am not sure that the estimate of some witnesses of twice this weight is not more nearly correct), we will have, during the same period, a daily loss of twenty-five hundred million pounds, equal to three hundred thousand millions for the season.

"This estimate applies to three or four year old fish, of at least three to five pounds in weight. We must, however, allow for those of smaller size, and a hundred-fold or more in number, all engaged simultaneously in the butchery referred to.

"We can scarcely conceive of a number so vast; and however much we may diminish, within reason, the estimate of the number of Bluefish and the average of their captures, there still remains an appalling aggregate of destruction. While the smallest Bluefish feed upon the diminutive fry, those of which we have taken account capture fish of large size, many of them, if not capable of reproduction, being within at least one or two years of that period.

"It is estimated by very good authority that of the spawn deposited by any fish at a given time not more than thirty per cent. are hatched, and that less than ten per cent. attain an

age when they are able to take care of themselves. As their age increases, the chances of reaching maturity become greater and greater. It is among the small residuum of this class that the agency of the Bluefish is exercised, and whatever reasonable reduction may be made in our estimate, we cannot doubt that they exert a material influence.

"The rate of growth of the Bluefish is also an evidence of the immense amount of food they must consume. The young fish which first appear along the shores of Vineyard Sound, about the middle of August, are about five inches in length. By the beginning of September, however, they have reached six or seven inches, and on their reappearance in the second year they measure about twelve or fifteen inches. After this they increase in a still more rapid ratio. A fish which passes eastward from Vineyard Sound in the spring, weighing five pounds, is represented, according to the general impression, by the ten to fifteen pound fish of the autumn. If this be the fact, the fish of three or four pounds which pass along the coast of North Carolina in March return to it in October weighing ten to fifteen pounds.

"As already explained, the relationship of these fish to the other inhabitants of the sea is that of an unmitigated butcher; and it is able to contend successfully with any other species not superior to itself in size. It is not known whether an entire school ever unite in an attack upon a particular object of prey, as is said to be the case with the ferocious fishes of the South American rivers; should they do so, no animal, however large, could withstand their onslaught.

"They appear to eat anything that swims of suitable size—fish of all kinds, but perhaps more especially the menhaden, which they seem to follow along the coast, and which they attack with such ferocity as to drive them on the shore, where they are sometimes piled up in windrows to the depth of a foot or more.

"The amount of food they destroy, even if the whole of it be not actually consumed, is almost incredible. Mr. Westgate (page 33) estimates it at twice the weight of the fish in a day, and this is perhaps quite reasonable. Captain Spindle goes so far as to say that it will destroy a thousand fish in a day. This gentleman is also of the opinion that they do much more harm to the fishes of the coast than is caused by the pounds. They will generally swallow a fish of a very large size in proportion to their own, sometimes taking it down bodily; at others, only the posterior half. The peculiar armor of certain fish prevents their being taken entire; and it is not uncommon to find the head of a sculpin or other fish, whose body has evidently been cut off by the Bluefish. In the summer time the young are quite apt to establish themselves singly in a favorite locality, and, indeed, to accompany the fry of other fishes, usually playing below them, and every now and then darting upward and capturing an unlucky individual, while the rest dash away in every direction. In this manner they attend upon the young mullet, atherinas, etc. They are very fond of squid, which may very frequently be detected in their stomachs. In August, 1870, about Fire Island, Mr. S. I. Smith found their stomachs filled with marine worms, a species of *Heteronereis*, which, though usually burrowing in the mud, at that season swims freely toward the surface *in connection with the operation of reproduction. This, like the squid, is a favorite bait for the* Bluefish; and they appear to care for little else when these are to be had. This fact probably explains the reason why, at certain seasons, no matter how abundant the fish may be, they cannot be taken with the drail or squid boat."[1]

[1]The following extract from the "Gloucester Telegraph" of June 4, 1870, gives an idea of their influence upon other fishes:

"ABUNDANCE OF FISH IN NEW JERSEY—1870.—Accounts from New Jersey say that the Bluefish came in at Barnegat Inlet last week, sweeping through the bay, over flats as well as through the channel, driving millions of bushels of bunkers before them and filling the coves, creeks, ditches, and ponds in the meadows full. At Little Egg Harbor Inlet they drove shad on shore so that people gathered them up by wagon-loads. Fish lie in creeks, ponds, etc., along

The Bluefish are believed to have had a very important influence upon the abundance of other species on some parts of the coast. This has been noticed especially on the north side of Cape Cod. South of Cape Cod the small fish occur in such enormous abundance that even the voracity of millions of Bluefish could hardly produce any effect upon them. Captain Atwood has recorded his belief that the advent of the Bluefish drove away the plaice or large flounder from those waters, not so much by their direct attacks upon them as by destroying the squid upon which the latter formerly subsisted. He is also of the opinion that the mackerel once, for a time, were affected by them. The mackerel have since returned to those waters in their wonted numbers, but the Bluefish are not now sufficiently plenty north of Cape Cod to interfere with them. The flight of the mackerel was not an unmitigated evil, however, since, as Captain Atwood pointed out, the number of lobsters for a time was very considerably increased. The mackerel fed upon their eggs, and when they were driven away by the Bluefish the lobsters had a better chance to multiply.

"The Bluefish sometimes make their way up the rivers to a considerable distance, the adults, however, apparently never entering the perfectly fresh water. They are found in the Potomac as far north as Aquia Creek, and also far up the Hudson; indeed, the young of the year are taken as high as Sing Sing on the Hudson and other tidal rivers, where the water is entirely fresh."

REPRODUCTION.—"Little is known of their reproduction. Dr. Yarrow does not give any facts in regard to this subject, at Fort Macon, except that spawn was seen to run out of a small female caught July 14. Dr. Holbrook is also silent on this head. Mr. Genio C. Scott says the spawning beds are visited by the parent in June, and consist of quiet nooks or bays. Mr. R. B. Roosevelt states that very diminutive young occur in immense numbers along the coast at the end of September or beginning of October ('Game Fish of America,' 1862, 159). I found the young fish at Carson's Inlet, Beasley's Point, New Jersey, in July, 1854, two or three inches in length, and more compressed than the adult; but farther east, on Vineyard Sound, although diligent search was conducted, between the middle of June and the first of October, with most efficient apparatus in the way of fine-meshed nets, I met with nothing excepting fish that made their appearance all at once along the edge of the bay and harbor.

"According to Captain Edwards, of Wood's Holl, a very accurate observer, they have no spawn in them when in Vineyard Sound. This statement is corroborated by Captain Hinckley; and Captain Hallett, of Hyannis, 'does not know where they spawn.' The only positive evidence on this subject is that of Captain Pease, who states it as the general impression about Edgartown that they spawn about the last of July or the first of August. He has seen them when he thought they were spawning on the sand, having caught them a short time before, full of spawn, and finding them afterward for a time thin and weak. He thinks their spawning ground is on the white sandy bottom to the eastward of Martha's Vineyard, toward Muskeeget. While not discrediting the statement of Mr. Pease, it seems a little remarkable that so few persons on the eastern coast have noticed the spawning in summer of the Bluefish; and, although there may be exceptions to the fact, it is not impossible that the spawning ground is in very early spring, or even in winter, off New Jersey and Long Island or farther south. It is not impossible that, at a

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the meadows two feet deep, so that one can take a common fork and pitch them into a boat or throw them on the bank. In some places they lie in windrows on the meadows where the tide has taken them, so they take large wood-scows alongside and load them."

1857.—"Bluefish were very plenty off our shores in the early part of autumn. They are great enemies to the menhaden; and for several days such a war raged that the beaches were strewn with dead fish, chiefly of the latter species. Mr. Lewis, the historian, said that in two tides he picked up nine bushels and buried them in his garden for manure.—LEWIS AND NEWHALL, p. 452. History of Lynn.,

suitable period after spawning, the young, in obedience to their migratory instinct, may move northward along the coast, growing rapidly as they proceed. This explains the almost sudden appearance of fish of five inches about Wood's Holl.

"We have the statement of Dr. Yarrow that vast schools of small Bluefish were met with in Beaufort Harbor during the last week in December, 1871. These were in company with small schools of young menhaden and yellow-tail shad, and were apparently working their way toward the sea by the route of the inlet. When observed, they were coming from the southward through the sound, moving very slowly, at times nearly leaving it, and then returning. The largest were about four inches in length, and others were much smaller; and as many as twenty schools were observed from the wharf at Fort Macon, each of them occupying an area of from sixty to eighty feet square, and apparently from four to six feet in depth. I would not be much surprised if these fish should prove to have been spawned late in the year off the southern coast."

Diligent research by numerous inquirers during a period of ten years has failed to add anything of importance to what Professor Baird has already stated in the paragraph above quoted, and it may be regarded as almost certain that Bluefish do not spawn in our inshore waters. The only important contribution to our knowledge on this subject is found in the notes of Mr. Silas Stearns, who believes that he has abundant evidence of their spawning in the Gulf of Mexico. His remarks are quoted in full below. The Hon. Robert B. Roosevelt records that he observed the bluefish fry less than an inch in length in the inlet of Far Rockaway, New York, on the 10th of July.

SIZE.—"The size varies considerably with season and locality, those spending the summer on the southern coast, according to good authority, rarely exceeding two or three pounds in weight, and being generally considerably less. The largest summer specimens are those found farther to the eastward, where they are not unfrequently met with weighing from ten to fifteen pounds, although this latter weight is quite unusual. Mr. Snow, however (page 44), mentions having seen one of twenty-two pounds, and others give as their maximum from fourteen to twenty. The average size of the schools in Vineyard Sound, during the early season, is from five to seven pounds. The schools, however, that make their appearance in October embrace many individuals of from ten to fifteen pounds. It is, therefore, not improbable that the difference between the first-mentioned average and the last represents the increase by their summer feeding. As already remarked, Bluefish in the last century sometimes attained a weight of forty or fifty pounds in Vineyard Sound; according to Zaccheus Macy, thirty of them would fill a barrel."

"Forest and Stream," June 25, 1874, states that L. Hathaway, esq., a veteran fisherman, while fishing from the bridge at Cohasset Narrows, Massachusetts, with rod and reel, captured a Bluefish weighing twenty-five pounds. The largest previously caught weighed seventeen pounds.

"On getting back to the Carolina coast in the early part of November, according to Dr. Yarrow's statement, they are from three to five feet in length and weigh from ten to twenty pounds. What becomes of these large fish, that so few of them are seen in the early spring, it is impossible to say. If it be really true that they are much scarcer than in the fall, we may infer that their increased size makes them a more ready prey to the larger fish and cetaceans, or that they have accomplished their ordinary period of life; possibly that they have broken up into smaller parties, less conspicuous to observation, or that they have materially changed their locality. The average length of the fish that appear in the spring off the coast of Virginia and the southern part of New Jersey, according to Dr. Coues, Dr. Yarrow, and my own observations, is about one foot, being probably about one year old. As a general rule, those of the smaller size keep close to the shore and can always be met with, while the larger ones go in schools and remain farther outside.

"I was unable to obtain any very young fish about Wood's Holl in 1871, the smallest found making their appearance quite suddenly along the coast, especially in the little bays, about the middle of August, and then measuring about five by one and one-fifth inches. By the end of September, however, these had reached a length of seven or eight inches, and at the age of about a year they probably constitute the twelve or fourteen inch fish referred to as occurring along the southern coast. The fish of the third year, or those two years old, are possibly the three-pound fish, while the five to seven pound fish may be considered a year older still. Accurate observations are wanting, however, to determine these facts; as also whether they require two years, or three or more, to attain sufficient maturity for breeding. As far as I know, there is no appreciable difference between the sexes in their rate of growth or weight, excepting that the female is likely to be a little deeper in the body."

A Bluefish weighing one pound measures about fourteen inches; two pounds, seventeen inches; three pounds, twenty-one inches; four pounds, twenty-four inches; five pounds, twenty-six inches; six pounds, twenty-six to twenty-seven inches, and eight pounds, twenty-nine inches.

STEARNS ON BLUEFISH IN THE GULF OF MEXICO.—Mr. Stearns' notes on the occurrence of the Bluefish in the Gulf of Mexico are so important that they are quoted here in full:

"The Bluefish is abundant in West Florida and as far west as the Mississippi River, but is rare or not found at all in other parts of the Gulf. At Pensacola and vicinity it is at certain seasons one of the most important fishes of trade. Here it is caught only in seines and when migrating, during the months of April, May, June, November, and December. It usually appears on the coast in April—sometimes a little sooner—and comes from the southeast, swimming directly in from deep water, or parallel to the land, according to the condition of the sea. It sometimes swims near the surface, either to sport or prey upon smaller surface-swimming fishes, but more commonly at some depth in shoal water along the beach. Many schools are observed through the months of April, May, and June approaching the land from the eastward, and it is supposed that there are several distinct 'runs' in that period. These 'runs' take place every year, although much larger some years than others. It is usually the case that the fish arriving in the spring are small, averaging two and a half pounds weight, and that those caught in the fall are larger, averaging four pounds or more. A few very large individuals are found in both seasons.

"In May and June Bluefish enter the bays. They remain for some days in the swift tideways when inside, and then disappear almost entirely from observation. A few are taken through the summer with hook and line in the bays and at sea. Excepting the smallest ones, all the Bluefish contain spawn when they arrive in the spring. With the larger fish the spawn is nearly ripe, and with the small and intermediate size is found in nearly all stages. April 29, 1879, I examined two female Bluefish, weighing seven and eight pounds, and found spawn almost ripe enough to flow from the oviduct. The same day others, smaller ones, were examined, in which the ovaries were scarcely visible. The spawning season of the Bluefish includes several months, I think, which are May, June, July, and August.

"There can be no doubt of its spawning in the bays, sounds, and bayous, as all evidence gained goes so far to prove it. On June 18, 1878, and August 9, 1878, I caught young Bluefish of about three-quarters of an inch in length in Pensacola Bay. These fry were very active and gave me no little trouble in capturing them. Their color was a brilliant green, which faded considerably when placed in alcohol. These, with others, were sent to the National Museum with my collections of that year. Many other specimens of about that size were seen in August, but escaped my net. During the months of November and December many small schools of Bluefish are seen to pass out of the inlets, and, if there is not much surf, to follow along the beach eastward.

Bluefish of all sizes may be seen at this time, the smaller ones measuring in length three to five inches, the intermediate sizes ten, twelve, and fifteen inches, and the large ones from the last-mentioned size to a size weighing fifteen or eighteen pounds. Ten pounds is not an unusual weight for large Bluefish, but those of eighteen pounds are rare. Bluefish are said to be more abundant on this coast than formerly, and any change in the last five years has tended to an increase rather than a decrease. It is an exceedingly voracious fish, preying upon any kind of fish through which its teeth can cut and which its jaws can surround. I think its migratory movement on this coast is caused more on account of its food becoming scarcer in cold weather than on account of its being influenced by the change of the temperature of the water, for on the coldest days of the year (in December) Bluefish are sometimes caught in shoal water in great abundance as well as at any other time. The Bluefish is one of the choicest food-fishes of this coast, and is much used, both fresh and salted."

EARLL ON THE BLUEFISH IN NORTH CAROLINA.—Below is given an outline of the winter Bluefish fisheries of the Southern coast as gathered from notes made during the visit of Mr. R. E. Earll to that region:

The large fish are taken in two localities—first, a few miles off Cape May, and again on the Carolina coast between Cape Henry and Ocracoke Inlet. They are most abundant between Cape Hatteras and New Inlet. Small fish frequently enter the sounds during the summer months, and have long been taken by the residents. The larger ones seldom enter the inlets, but remain near the outer shore, where they feed upon the menhaden, shad, and alewives, during the season of their migrations to and from the larger sounds in fall and spring.

Apparently, the first that was known of the presence of large Bluefish in this region was in 1842, when a quantity was taken in a haul-seine near New Inlet. Gill-nets were first used for the capture of the species in this locality in 1847, though they were not generally adopted till several years later. The first vessel visited the region in 1866, and from that date to 1879 six to twelve sail came regularly to the locality. The fishery reached its height between 1870 and 1876, when in addition to the vessels fully one hundred crews of five men each fished along the shores. The catch varies greatly from time to time, as the fish are constantly on the move and often go beyond reach of the seines and gill-nets. Some seasons each boat's crew has averaged four or five thousand fish weighing ten to fifteen pounds each, and again they have taken almost nothing. Frequently the bulk of the catch of an entire season is taken in three or four days.

Since the winter of 1877 and 1878 the fish are said to have been much less abundant and of smaller size. In the winter of 1879 and 1880 about seventy-five crews were engaged in the fishery from the first of November till Christmas. The total catch did not exceed fifty thousand fish averaging six pounds each. The small number taken is partially accounted for by the fact that many of the fish were so small as to readily pass through the meshes without being caught.

During my visit in May, 1880, large schools of Bluefish were reported along the shore, and a considerable number of shad and other species were found upon the beach where they had been driven by their pursuers. A good many Bluefish were also stranded while in pursuit of their prey. It seemed that there is no reason to believe that the fish have permanently left the coast, or that they are even so scarce as is at present claimed, for the men have fished with little regularity, and have gone only a short distance from the shore, while the bulk of the Bluefish may have been farther out.

USES.—This is one of the most important of our food-fishes, and surpassed in public estimation only by the Spanish mackerel and the pompano. It may be said to furnish a large part of the supply to the middle and Northern States. It is a standard fish in New York, Boston, and

other seaports, and is carried in great numbers into the interior. Its flesh is very sweet and savory, but it does not keep very well. In the Vineyard Sound the fishermen are in the habit of crimping their fish, or killing them, by cutting their throats in such a manner that they bleed freely. Every one who has opportunities for observing admits that fish thus treated are far superior to any others. Great quantities of Bluefish are frozen in New York for winter consumption. They are still considered unfit for food on our Southern coast, and even in the markets of Washington, District of Columbia. I have frequently been stopped by fish-dealers who asked me to assure their customers that Bluefish were eatable. They are growing into favor everywhere, however, just as they did in Boston. Captain Atwood tells me that in 1865 but very few were sold in Boston, and that the demand has been increasing ever since. When he first went to Boston with a load of Bluefish he got two cents a pound for them; the second year they were scarcer and he got two and one-half cents, and the year afterwards three cents.

147. THE COBIA OR CRAB-EATER—ELACATE CANADA.

This fish, known in the Chesapeake Bay as the "Bonito" and "Coal-fish," and as the "Sergeant-fish" in Southern and Eastern Florida, and in Western Florida as the "Ling" or "Snooks," is considered one of the most important food-fishes of Maryland and Virginia, though it is but little known elsewhere. Like the Bluefish, it is cosmopolitan in its distribution, having been recorded in the seas of China and Japan, in Southeastern Hindostan, in the Malay Archipelago, on the coast of Brazil, in the West Indies and the Bermudas, where it is called the "Cubby-yew," and along our own shores from the Gulf of Mexico to Cape Cod. DeKay speaks of the capture of a single individual in Boston Harbor. The species was originally described by Linnæus from a specimen sent to him from South Carolina by Dr. Garden. The name "Sergeant-fish" refers to its peculiar coloration, several stripes of brown and gray being visible on the sides of the body. The name "Crab-eater" appears to have been ascribed to the fish by Dr. Mitchill. What is known of its habits may be very shortly told. Holbrook remarks: "The Crab-eater is a solitary fish; it prefers deep and clear water and is only taken singly with a hook. It lives on the coast of Carolina late in May, and is occasionally captured until September, when it is no longer seen in our waters. It is exceedingly voracious, and destroys many smaller fish, which make its ordinary food, though it does not reject crustaceous animals."

Mitchill cut up a specimen which he obtained in New York market in June, 1815, which had been caught in the bay. He found its stomach distended with food of various sorts, including twenty spotted sand-crabs and several young flounders. DeKay tells us that the specimen from which his description was taken was captured in a seine in the harbor of Boston and placed in a car with other fish. It was soon discovered that he had destroyed and eaten every fish in the car. These fish were chiefly sculpins or porgies. Mr. S. C. Clarke, speaking of the fish fauna of Florida, remarks: "This fish I have never seen except in the Indian River, where it is a common species, lying under the mangrove bushes in wait for prey like a pike, which it much resembles in form and in the long under jaw full of sharp teeth." The size is from two to three feet. It attains the length of five feet and the weight of fifteen or twenty pounds. Stearns writes: "It is said by Maj. E. B. Staples, of Sarasota, to be quite common in South Florida."

The Cobia breeds in the Chesapeake Bay, where in 1880 Mr. R. E. Earll succeeded in artificially fertilizing the eggs. Dr. Mitchill speaks of its availability as a food-fish in the highest terms.

148. THE TRIPLE-TAIL OR BLACK PERCH—LOBOTES SURINAMENSIS.

The Triple-tail of the New York market, *Lobotes surinamensis*, known in South Carolina as the "Black Perch," and to the fishermen of Saint John's River as the "Grouper," is also called

by various authors the "Black Triple-tail," and in 1856, according to Gill, was called in New York market the "Flasher." It is remarkable on account of its extraordinarily wide range, having been found in China, the Malay Archipelago, at Sunda and Molucca, in the Bay of Bengal, and in the Mediterranean about Sicily; at Ceylon, in the West Indies about Cuba and Jamaica, on the coast of South America, from Surinam, whence the first specimen was derived and from which locality the species takes its scientific name, and along the coast of the United States from Saint John's River to Wood's Holl, Massachusetts. The Triple-tail is a short, thick, heavily built fish. The dorsal and anal fins project backwards towards the base of the caudal so prominently as to give origin to the common name. When alive it is a very beautiful species, silvery and gray in color, but after death it soon becomes dingy—so dingy, in fact, that many of the common names are prefixed by the adjective "black." I saw four specimens at Jacksonville, Florida, on the 5th of April, 1875. The largest weighed about ten pounds and measured nearly two feet in length. The species is abundant about Charleston, where, according to Holbrook, it appears in June and remains until September. It feeds upon small fishes and mussels, and is said to take the hook readily when baited with clams or with shrimps. It is occasionally taken in the lower part of the Chesapeake Bay, and Professor Baird obtained specimens about three inches long in August among the eel-grass on Tuckahoe River in New Jersey. Stragglers have been taken at New York, and even as far north as Wood's Holl, Massachusetts. They are occasionally brought to the New York market, where they are highly esteemed. Gill, writing in 1856, said: "I saw a single specimen of this species in Fulton Market last year, which remained exposed on the stall from August 30 to September 6. It did not seem to be known. It was about fifteen inches in length, and one dollar was demanded for it." By the fishermen of Saint John's River, Florida, it is considered one of the finest food-fishes, and its large silver scales command a high price at the fancy shops, where they are sold to be used in the manufacture of scale works.

149. THE MOON-FISH—CHÆTODIPTERUS FABER.

The Moon-fish is one of the rarer species on our coast, and has recently come so much into favor in New York that among connoisseurs it is one of the most highly esteemed food-fishes. It is also highly esteemed by residents of Washington who know it, being abundant in the markets of that city in summer. In the northern parts of the Gulf of Mexico it is called the "Spade-fish"; from Florida to Charleston the "Angel-fish," a name which, according to Schoepf, appears to have been current during the last century at Beaufort, North Carolina, where it is called the "Porgee" or "Pogy," and at New York, where it is stated to be found in summer. "Three-tail Sheepshead" and "Three-tail Porgee" are names which are said to have been formerly in use among the New York fishermen.

The range of this species along our coast is very wide. It has been found in Guatemala, and perhaps farther south, and the British Museum has specimens from Texas, Santo Domingo, and Jamaica. It is said to be somewhat abundant on the coast of South Carolina, and not uncommon at the entrance to the Chesapeake Bay. They are occasionally taken about New York, and several individuals have been obtained by the Fish Commission at Woods' Holl. It is occasionally taken in Southern California, about San Diego. It attains the length of eighteen inches and the weight of several pounds. The large adult specimens have a peculiar globular bone in the head, unlike anything which has been found in any other fish. Two species have been recognized by American ichthyologists. It seems probable that these represent different ages of the same fish. The only study of its habits in existence is the following, which is quoted from Mr. Stearns' manuscript:

"The Spade-fish, *Chætodipterus faber*, is common on the West Florida, Alabama, and Louisiana

coasts. I have not observed it in South Florida. It is found throughout the summer and fall in the bays, about wharves, rock-piles, and old wrecks, where crustaceous animals are abundant. In October and November large schools are seen along the sea-beaches, evidently leaving the coast for warmer waters, at which time many are caught by seine fishermen. It spawns in early summer, and the young are seen until October. I have seen specimens of Spade-fish fifteen inches long; but the average size is not more than eight inches. It is an excellent pan-fish, selling readily in market."

This species is known to the fishermen of the Saint John's and Indian Rivers, Florida, under the name "Angel-fish." Holbrook states that it appears on the shores of South Carolina in May and June, and is then taken in considerable numbers with the seine. Jordan states that it is common at Beaufort, North Carolina, where it is used as a food-fish. Lugger remarks that it is not uncommon in the salt-water region near the entrance to Chesapeake Bay, but is seldom, if ever, brought to the Baltimore markets. DeKay remarks that in the waters of New York it only appears periodically, and occasionally in great numbers during the summer months. About 1822 they were caught here in seines in great numbers, and exposed in the markets for sale. I am not aware that any such incursion has since been observed. On the coast of California, where, according to Jordan, it is occasionally taken about San Diego in the kelp, it is too rare to be of commercial importance.

150. THE REMORA FAMILY—ECHENEIDIDÆ.

This family is represented on our coast by five species, which are generally known as "Suckers" or "Sucking-fishes." They are among the most remarkable of fishes, the first dorsal fin having become transformed into a sucking organ, by means of which the fish can attach themselves very firmly to the sides of vessels or to the gill-covers or sides of larger species of fish. One or two of the species, such as the *E. naucrates*, are frequently found adhering to the sides of vessels. Others attach themselves to sharks, and are carried by them from place to place. Since they are themselves excellent swimmers, the purpose of this peculiar habit is hard to understand. It appears to be more for the purpose of following the larger fishes in order that they may share the fragments of their feasts. Very often, especially in the case of sharks, the fish to which the Suckers attach themselves become very much emaciated and exhausted by the effort of swimming under this impediment. The common sword-fish is frequently accompanied by one of the Sucking-fishes, which has been called the "Sword-fish Sucker," *Remoropsis brachyptera*. It has not been known to attach itself to any other fish. The "Bill-fish," *Tetrapturus*, has another species of sucker peculiar to itself, the Cuban "*Pega de las Agujas*" *Rhombochirus osteochir*.

Mr. Stearns states that in the Gulf of Mexico, when on the snapper banks fishing, he has seen these fish leave sharks that were in the vicinity and remain about the vessel as long as it staid there for the purpose of securing the bait that had been thrown overboard. He noticed some that were four or five feet in length. These "Sucking-fish" are never eaten, and are interesting chiefly as enemies of other more important species.

The Remora was one of the first fishes observed by the early discoverers of North America. In Ogilby's "America" is the following description of the manner in which the Indians used these fishes as aids in the capture of other larger species. The incident seems to have occurred about the West Indian islands:

"*Columbus* from hence (from Cuba) proceeding on further Westward, discover'd a fruitful Coast, verging the Mouth of a River, whose Water runs Boyling into the Sea. Somewhat further he saw very strange Fishes, especially of the *Guaican*, not unlike an Eel, but with an extraordinary

great Head, over which hangs a Skin like a Bag. This Fish is the Natives Fisher; for having a Line or handsom Cord fastned about him, so soon as a Turtel, or any other of his Prey, comes above Water, they give him Line; whereupon the *Guaican*, like an Arrow out of a Bowe, shoots toward the other Fish, and then gathering the Mouth of the Bag on his Head like a Purse-net holds them so fast, that he lets not loose till hal'd up out of the Water."[1]

[1] Narrative of Voyage of Columbus, in Ogilby's "America," 1671, p. 49 (with very curious picture of Indian fishing).

P.—BARRACOUTA, MULLET, PIKE, AND MUMMICHOGS.

151. THE BARRACOUTA FAMILY—SPHYRÆNIDÆ.

This family is represented on our Atlantic coast by several species, none of which appear to be at all abundant north of Florida, except one species, which has recently appeared in considerable numbers on the coast of Southern Massachusetts, and which is recorded by Jordan as abundant in its young state in Beaufort Harbor, North Carolina. This species, called by DeKay *Sphyræna borealis*, is closely related to, if not identical with, *S. spet* of the Mediterranean. No specimens of greater length than ten or twelve inches have ever been taken, and individuals of this size are very unusual, though smaller ones, ranging from two to six inches, are occasionally found in large schools about the western end of Martha's Vineyard and about Wood's Holl, Massachusetts. It seems incredible that the young should occur so abundantly in these waters and the full-grown individuals should be absent. This is, possibly, because we do not yet know how to capture them. The common Barracouta, or "Barracuda," of the West Indies, *Sphyræna picuda*, occasionally finds its way into our northern waters, and one or two specimens of them and other West Indian species have been taken at Wood's Holl.

S. picuda is the common Barracouta of Key West and the southern coast. It is caught with hook and line, and appears occasionally in the markets. Mr. Stearns states that it is only of average merit as a food-fish. He records the capture of several very small specimens belonging to this genus in Pensacola and Choctawhatchee Bays in June, 1880. In the West Indies this, or some closely related species, grows to the enormous length of eight feet and the weight of forty pounds, and is as much dreaded as the large sharks.

Although to some extent used as food, this is one of the forbidden fishes of the Cuban markets, there having been instances of severe sickness caused by eating its flesh. Since, however, a large part of the best food-fishes of the West Indian waters are tabooed by Cuban law, this is hardly to be regarded as a fair criterion. In the Bermudas both *Sphyræna picuda*, called "Sennet," and *S. spet*, which is called the "Barracuda," are highly esteemed for food and meet with ready sale.

On the California coast occurs another species, *Sphyræna argentea*, which is everywhere known as the 'Barracuda,' or 'Barracuta'; this species reaches a length of about three feet and a weight of twelve pounds.

Professor Jordan remarks concerning it as follows: "It is abundant in summer from San Francisco southward, great numbers having been taken everywhere from Santa Cruz southward. It is found mainly at a distance of three miles or more from the shore. In open water it will sometimes take a still hook, but near the shore it must be trolled for. It arrives in late spring or summer, at different times in different places, the main 'runs,' about the Santa Barbara Islands, being in July; farther north, somewhat later. It spawns at San Pedro about the 1st of August. In September it usually disappears, but the young often remain in the south and are taken with the seine in the winter. It is not known whether it retreats to the south or to deep water. It feeds upon anchovies and other fishes. As a food-fish it is one of the best and most important on the coast. It is highly esteemed when dried and salted, and, like the white-fish and yellow-tail, then sells at a price higher than that received for the Alaska codfish."

152. THE DEAL-FISH FAMILY—TRACHYPTERIDÆ.

The members of this family are found in the deep parts of the sea in various parts of the world, though none have yet been found on our Atlantic coast. They are eel-shaped fishes of great length and brilliant colors, and have even been described under the name of "Sea-serpent." It is probable that most of the stories regarding the "sea-serpent" have had reference to some member of this family, and to this family most of the descriptions of large marine animals of a serpent-like nature are very applicable. Several individuals of the species known as the "Oar-fish," *Regalecus Banksii*, have been cast up on the British coast, the largest in Yorkshire, in 1845, twenty-four feet in length. In 1860, an individual, eighteen feet in length, ran ashore at the Bermudas, but none have been found in the more western portions of the Atlantic, although descriptions which have been given by various observers would indicate that they occasionally appear near our shores. On the Pacific coast there is a species which is sometimes cast ashore by the storms, *Trachypterus altivelis;* it is considered by the Makah Indians to be the King of the salmons, and they will permit no one to eat the flesh upon any condition, for fear the salmon will never return. It is curious that a similar tradition exists on the coast of Norway regarding a related species which is called the "Sillkung," or "King of the herring." "The same notion," says Jordan, "is commemorated in the generic name *Regalecus*."[1]

153. THE MULLETS—MUGIL ALBULA AND MUGIL BRASILIENSIS.

NAMES.—There are,upon our coast two species of Mullet, the differences between which are sometimes, though not always, recognized by fishermen. The most usual species is the Striped Mullet, *Mugil albula;* the other is the so-called "White Mullet," *Mugil brasiliensis*. The former is the larger, and has eight instead of nine rays in the anal fin, and forty-two instead of thirty-eight scales between the gill openings and the base of the caudal fin. There has been so much confusion among writers regarding the species of this family upon our coast that it has until very recently been impossible to define precisely their geographical range. The Striped Mullet occurs in the West Indies, the Gulf, and from Southern California to Chili, the other species from Southern Massachusetts to the West Indies, and from Lower California to Peru. A single specimen of *M. brasiliensis*, was taken at Provincetown, in November, 1851. North of New Jersey the capture of a large individual is very unusual. In July great numbers of them, about an inch in length, have been observed on the Connecticut coast, especially in the vicinity of Noank; the fishermen there call them by the name of "Bluefish Mummichog." On various parts of the coast they have special names, which, however, do not appear to refer to special peculiarities. About Cape Hatteras the names "Jumping Mullet" and "Sand Mullet" occur; in Northampton County, Virginia, "Fat-back," and in Southeastern Florida "Silver Mullet" and "Big-eyed Mullet." The name "Fat-back" is also in use, but whether this name is used for Mullets in general, or simply for those in particularly good condition, I have been unable to learn. In the Gulf of Mexico the Striped Mullet is known simply as the "Mullet"; the other species as the "Silver Mullet."

GENERAL HABITS.—There are seventy or more species of Mullets, one or more of which are found on every stretch of coast line in the world in the temperate and tropical zones. They live in the sea, and in the brackish waters near the mouths of rivers. They, like the menhaden, though indeed to a still greater degree, subsist on the organic substances which are mingled with the mud and sand on the bottom.

"In order to prevent the larger bodies from passing into the stomach, or substances from

[1] *Rex—halec*=King of Herring.

passing through the gill openings, they have the organs of the pharynx modified into a filtering apparatus. They take in a quantity of sand and mud, and after having worked it for some time between the pharyngeal bones, they eject the roughest and most indigestible portion of it. Each branchial arch is provided on each side, in its whole length, with a series of closely set gill-rakers, which are laterally bent downward, each series closely fitting into the series of the adjoining arch; they constitute together a sieve, admirably adapted to permit a transit for the water, retaining, at the same time, every other substance in the cavity of the pharynx. The intestinal tract is no less peculiar, and the stomach, like that of the menhaden, resembles the gizzard of a bird. The intestines make a great number of circumvolutions, and are seven feet long in a specimen thirteen inches in length."[1]

ABUNDANCE.—Although Mullets are abundant almost everywhere, it is probable that no stretches of sea-coast in the world are so bountifully supplied with them as those of our own Southern Atlantic and Gulf States, with their broad margin of partially or entirely land-locked brackish water and the numerous estuaries and broad river mouths. The Mullet is probably the most generally popular and the most abundant fish of our whole southern seaboard. Like the menhaden, it utilizes food inaccessible to other fishes, groping in the bottom mud, which it swallows in large quantities. Like the menhaden, it is not only caught extensively by man, but is the main article of food for all the larger fishes, and is the best bait fish of the regions in which it occurs. In the discussion of the habits of the Mullet, when it is not otherwise stated, the Striped Mullet, which is in our waters by far the most important species, is kept chiefly in mind.

Since the time of Capt. John Smith every observer has remarked upon the great abundance of Mullets. Numerous correspondents of the Fish Commission, from Wilmington south, agree that the Mullet is far more abundant than any other species, except Mr. Simpson, who thinks that at Cape Hatteras they are less numerous than the tailors or bluefish, and about as numerous as the fat-backs or menhaden.

In 1875 circulars were sent out by the United States Fish Commission asking information concerning the habits of the Mullet. The replies, although suggestive, were not sufficiently numerous to afford the data necessary for a complete biography of this species. In fact its habits are so peculiar that in order to understand them it will be necessary for some naturalist to devote a considerable period of time to study them throughout the whole extent of their range. At present, therefore, I propose to present first the results of my own observations upon this fish, as it occurs in Eastern Florida, supplementing them by the observations of three or four other observers upon the Atlantic coast, and the excellent study of the Gulf Mullet from the pen of Mr. Stearns.

MULLET IN EASTERN FLORIDA.—They abound in the Saint John's River, sometimes running up to the lakes, and along the coast in all the inland bays, or "salt-water rivers". It is probably incorrect to call them anadromous. They appear to ascend the rivers to feed, and the relative saltness of the water is a matter of small importance. Small Mullet are abundant all the year round, and so are scattered individuals of a larger size. Cast-nets at Mayport take them throughout the year. I have taken quantities of small fish, from one to five inches long, in the Saint John's River at Arlington. They begin to assemble in schools in midsummer. This is probably preparatory to spawning, for at this time the ova are beginning to mature. In midsummer they swim at the surface, pursued by enemies in the water and the air, and are an easy prey to the fisherman. They prefer to swim against the wind, and, I am told, school best with a northeast wind. They also prefer to run against the tide. The spawning season appears to continue from the middle of

[1] This description of the anatomy of the Mullet is derived from Günther's "Study of Fishes."

November to the middle of January, and the weight of evidence tends to show that they spawn in brackish or salt water. Some of the fishermen say that they go on the mud-flats and oyster-beds at the mouth of the river to deposit their eggs. What becomes of them after this no one seems to know, but it is probable that they spread themselves throughout all the adjacent rivers, bays, and sounds, in such a manner as not to be perceptible to the fishermen, who make no effort at this time to secure the spent, lean fish. Many of them probably find their way to the lakes, and others remain wherever they find good feeding ground, gathering flesh and recruiting strength for the great strain of the next spawning season. There is no evidence of any northern or southern coast-wise migration, the habits of the species apparently being very local.

The fisherman recognizes three distinct periods of schooling or separate runs of Mullet. To what extent these are founded on tradition, or upon the necessity of change in the size of the mesh of their nets, it is impossible to say. The "June Mullet" average about five to the pound; the "Fat Mullet," which are taken from August 20 to October 1, weigh about two pounds; these have, the fishermen say, a "rod of fat" on each side as thick as a man's thumb. The "Roe Mullet" weigh about two and a half pounds, and are caught in November and until Christmas. Between the seasons of "Fat Mullet" and "Roe Mullet" there is an intermission of two or three weeks in the fishing. How to interpret these curious statements is surely a difficult problem, and one which can be solved only by careful study of the fishes themselves at these seasons. The fishermen insist that these schools come successively down the river and proceed directly out to sea. They will not believe that the "Fat Mullet" and the "Roe Mullet" are the same schools under different circumstances. I would hazard the suggestion that the "Fat Mullet" of September are the breeding fish of November, with roes in an immature state, the ova not having become fully differentiated.

The largest fish appear rarely to exceed six pounds. This is exceptional, however. Mr. W. H. Tate, of Melton & Co., Jacksonville, tells me that he never saw one exceeding seven pounds, though he had heard of one weighing fourteen. He showed me on the floor of the fish-market a line indicating the length of a very large one; this measured twenty-nine inches. At Mayport none had been seen exceeding six pounds in weight. At the mouth of the Saint John's cast-nets of ten feet in diameter are used, but most Mullet are taken in gill-nets, which are swept around the school, the fish being easily visible at the surface.[1] These nets are from seventy to ninety fathoms long and forty meshes deep. The size of the mesh varies with the season. Very few are used from December to July, but where they are used the mesh two and one-half to two and three-quarters inches is preferred; from August 1 to October 1, for "Fat Mullet," the mesh is three and one-half to three and three-quarters inches, and in late October, November, and December, for "Roe Mullet," four inches—at least so said my informant, an intelligent negro fisherman. At Mayport there are two sweep-seines, seventy-five fathoms long and thirty feet deep, belonging to Kemp, Mead & Smith, used in the mullet fishery.

There is a large trade in fresh Mullet iced, of the extent of which I could gain but little idea: they are shipped chiefly to Central Florida and Georgia. Some have been sent in ice to Atlanta. About twenty thousand are shipped from Yellow Bluffs, by way of Jacksonville.

It is the general opinion of the fishermen that the Mullet have greatly diminished in abundance of late years, and that they are not one-third as plenty as they were ten years ago. This falling off is attributed to the presence of steamers, to the chances of the seasons, and, most of all, to the use of small-meshed seines, which catch the young fish in great numbers, and to the constant fishing by numerous nets, which destroys a large proportion of the mother-fish from year to year. Mr. Isaac

[1] "Roe Mullet" are often taken in a drift gill-net. When the net is being set it is customary to drum with the oars on the gunwale of the boat to make the fish "gill" better.

Balsam, of New Berlin, told me that ten or twelve years ago a man with a cast-net could easily take four or five hundred Mullet in a day, while now it is difficult to get any; this is due in part to their shyness. Mullet were comparatively scarce in the Saint John's in 1877, though plenty in 1876. The fishermen with whom I have talked favor the passage of laws prohibiting the use of gill-nets with a smaller mesh than three inches, and thus to allow the escape of the young fish, and of a close time during which fishing shall cease—for instance, from Saturday night to Monday morning. And then they say, with a regretful shake of the head, that the Mullet always run best on Sunday. There are probably one hundred or more mullet nets on the Saint John's, yielding an average of perhaps five thousand Mullet each annually. The fisheries are chiefly carried on by negroes in small boats, dug-outs, and skiffs, although every resident fishes for Mullet in summer when there is nothing else to do, and when the Mullet is the best food and the easiest obtained. There is no salting business of commercial importance in East Florida, though considerable quantities are put up for domestic consumption. Salt Mullet sell at the rate of eight or ten dollars a barrel, or five or six fish for twenty-five cents. I had an opportunity of tasting some salted by a negro at Mill Cove, and can bear testimony to their excellence. Their flavor is more like that of a salted salmon than of a mackerel, and they are hard, toothsome, and not at all "muddy" in taste, this last being the usual charge made against the Mullet. Usually only the "Fat Mullet" are salted, the "Roe Mullet" coming later in the season, when they can easily be shipped.

To prepare a Mullet for salting, the head is first cut off, then a cut is made on each side of the back-bone, down the back, and the bone is removed; the fish may then be spread out flat and packed in a barrel. In packing, the flesh side is carefully placed up, the skin down. The fish are spread out flat upon the skin side and are laid in tiers across the bottom of the barrel, each tier being covered with salt. Care is taken to have the direction of the bodies in the different tiers at right angles to each other. When the Mullet are scaled before packing they command a somewhat higher price. Mullet roes, though usually eaten fresh, are sometimes salted and dried in the sun. In this condition they are eaten raw, like dried beef, or are fried. Large ones sell for ten cents a pair. Fishermen often boil the heads to extract the oil, which they use to lubricate their guns.

"In the Lower Saint John's," according to Capt. David Kemps, an experienced Connecticut fisherman who has lived and fished for twelve years at Yellow Bluffs, "the Mullet are resident throughout the year, though most abundant in September and October. The fishing season begins in July and August and continues until December. They are three times more abundant than any other species, though not half as abundant as they were ten years ago. The decrease in numbers is due in part to the fisheries, but chiefly to the great number of steamers. The largest Mullet weigh eleven pounds and are twenty-three inches long; this, however, is above the average size, which measures thirteen inches and weighs two and a half pounds. They attain their growth in four years, each year adding half a pound to their weight. They school best in easterly weather, the schools being largest toward the end of the season. They swim at the surface, and usually against the wind. The "Fat Mullet" come down the river in August and September, and rapidly increase in size, becoming "Roe Mullet" in October and November. They feed by suction and on blind mosquitoes. They run out into salt and brackish water to spawn. They are supposed to spawn in November, on the shallows near the mouth of the river, in warm and brackish water. When they are caught in the gill-nets the spawn runs out of them; it is of the size of No. 3 shot, and red; it floats at the surface until it is hatched, which takes place in about three days. They spawn at about four years of age, the fish mixing indiscriminately in the schools. Cat-fish and eels prey

upon the eggs. They are caught chiefly on the flood-tides with gill-nets and seines. A gill-net seventy-five fathoms long will take ten thousand in a season. They are eaten fresh, commanding a price of one to five cents a pound, and are salted largely. About seventy-five boats and one hundred and fifty men are employed in the Lower Saint John's."

In the Saint Mary's River.—"At the mouth of the Saint Mary's," according to Mr. W. E. Myers, "the Mullet is resident and more abundant than any other fish, especially in August, September, October, and November. The general abundance is not apparently changed, though the supply varies. The average "Finger Mullet" is about four and a half inches long, while the "Sea Mullet" ranges from eight to eighteen inches, weighing from eight ounces to two pounds. They never leave this region, but spend the whole time in the salt-water bayous along the coast. They frequently run up into brackish or almost fresh water, probably for the purpose of feeding. Fishes of all sizes and ages mingle together in the schools. Their favorite haunts are on the shallow mud-flats and up little creeks or "rivers." At high water they feed among the black rushes or marsh grass. The shallows which they frequent are warmer than the off-shore water. After spawning they are generally found in small schools. They are preyed upon by porpoises, sharks, fish-hawks, cranes, and gulls. They feed on bottom mud and floating scum, also on shrimps. They spawn around their feeding-grounds in August and September, and young Mullets are always found in abundance in company with the old. Fish-lice are found in their gills. At Saint Mary's they are caught exclusively in cast-nets—the Spanish and American kinds—at all seasons, but chiefly in August and the fall months. They are usually caught in the last quarter of the ebb and first quarter of the flood tide. They are caught only in small quantities for home consumption, and are more in demand than any other fish, selling for about eight cents per pound. Very few are salted."

In Southeastern Florida.—At Saint Augustine, according to Mr. Peter Masters, Mullet are resident, but most abundant in September and October. They are thought to have diminished, "owing," says Mr. Masters, "to the gill-nets on the Saint John's." They move in and out of the harbor, over the Saint John's and Smyrna Bars. They run into fresh water three months in the year. They spawn in deep water in November and December. Thirty or forty men with small boats are engaged in the fishery, using gill and cast nets. The Mullet is the favorite food-fish, commanding a price of three or four cents per pound. Very few are salted.

About New Smyrna, says Mr. S. C. Clarke, the "Silver or Big-eyed Mullet," though resident, are most plenty in November, December, and January, and have for years retained their abundance, which is much greater than that of any other fish. The average size is three pounds, though they sometimes weigh four or five; the female is the larger. They are always to be found in shoal water with muddy bottoms, spending the winter in the creeks and bays. They run into fresh water to feed. They swim in schools, assorted in uniform sizes, rippling the surface and thus attracting predatory birds of all kinds, and followed by predatory fishes. The schools break up after the spawning season. They feed upon mud and floating scum. They spawn in large schools, in strong currents, in January and February; the eggs, which are yellow and about the size of mustard seed, floating at the surface in the currents and hatching within ten days. They prefer warm water for spawning. The roe often runs from the fish when caught. They spawn at the age of three years, and after spawning are thin and unfit for food. Young fish are seen in great abundance in shallow water near the shore; they are preyed upon by every fish and by every predatory bird. Mullet are taken with nets of all kinds, usually at low water. Some hundreds of barrels are put up yearly for shipment, commanding the price of six to eight dollars. They are also used for oil manufacture, and for manure.

Mr. H. S. Williams states that in the Indian River the Mullet season lasts from May until the

last of December, and during the whole time they are so numerous that scarcely a day passes in which some cannot be taken with proper exertion. In September they usually commence schooling, the schools increasing in size until the last of December, when they go outside to spawn, returning in January, February, and March, poor and tasteless. In November, 1876, he relates, he took one hundred and twenty-five from a single school with a cast-net in less than an hour's time, taking twenty-six large ones at a single throw. During the dark nights in October, November, and December, the Mullet swarm along the shore, feeding on the minute animals found in the sand and attached to the rocks, where they can be taken in great numbers, often thirty to fifty in a few minutes' time. They are preyed upon by all larger fish, from cat-fish to sharks, while porpoises, ospreys, eagles, and pelicans consume enormous quantities. The Mullet is here thought very fine either stewed, baked, or as a pan-fish. From the first of November to the end of the season they take salt as well as mackerel, and every resident family is accustomed to cure a barrel or two for private use.

STEARNS ON MULLET IN THE GULF OF MEXICO.—This chapter will be closed by quoting in full the observations of Mr. Silas Stearns:

"The Mullet is one of the most abundant and valuable food-fishes of the Gulf coast. It is present on the coast and in the estuaries of the Gulf throughout the year, and in most places is pursued by fishermen at all seasons, yet, for so common and important a fish, its habits seem to be but little known or understood. Intelligent fishermen of long experience at particular points have learned many details regarding their local movements, which may disagree in many respects with those at some other point a hundred miles or so away. A few months spent on the southern part of the Florida coast has led me to believe that there is a less migratory movement of Mullet in that section than along the northern Gulf coast. It is probable that in each bay or section or coast Mullet have peculiar habits as to time and manner of arrival, time and place of spawning, and the general habits of old fish after spawning and young after hatching. It is also likely that their manner of spawning, feeding, etc., is the same everywhere. My own observations have been chiefly made in Pensacola and Choctawhatchee Bays and Santa Rosa Sound, which take in fifty miles of coast line. In this section, which I have called the Pensacola region, there is a spring 'run' of Mullet composed of various sizes of young which are in part, no doubt, of the previous year's hatching. The first school of this run appears on the coast in April or in the first part of May, and they continue to come for two or three weeks, when they are all inside and scattered about the bay shores. These fish are very thin on their arrival, but rapidly fatten and grow on the feeding grounds. Some of these contain spawn at first, and in some it is developed during the summer.

"In September and October there is a 'run' of large fish, which comes, as the young one does, from the eastward, swimming at the surface of the water and making considerable commotion. Some years there is but one large school in the 'run' and at others many small schools, and it is thought that the fish are more abundant when they come in the latter form. At Choctawhatchee Inlet, when the spawning grounds are near by, the fish come in with the flood tide and go out again with the ebb tide; and at the Pensacola Inlet, when the spawning grounds are far away, they come into the bay and stay until the operation of spawning is over. The spawn in this fall 'run' is fully developed, and is deposited in October and November. The spawning grounds are in fresh or brackish water at the heads of bayous, in rivers or heads of bays. The many bayous of Choctawhatchee Bay are almost blocked up with spawning Mullet in October, and they are very abundant at the head of Pensacola Bay near the mouths of fresh-water rivers at that time. Although I have been in the bayous when Mullet were supposed to be spawning, I have not witnessed the operation,

nor seen any person who has. In such places the bottom is grassy, sandy, and muddy, the water varying with the tide from fresh to brackish, and of a temperature varying from 70° to 75° Fahrenheit. It is supposed that the spawn is deposited upon the bottom. If they have been spawning at the times when I have been present, I would say that the operation was a general one. That they do spawn at or near these places is quite certain, for they go to them with spawn and come away without it, and the young fry first appear near the same places. Crabs and alligator-gars are abundant in such places, and they doubtless destroy great quantities of the eggs and fry. Before spawning Mullet are very fat, but after the operation are extremely thin and almost worthless for food. Their colors also undergo some changes, at sea being bright blue on the back, which deepens to a light brown in the bays and to a dark brown in fresh water. By these characteristics it is not difficult to determine the locality where a lot of Mullet are caught.

"Some persons of this coast agree that Mullet, or any other sea-fish, will not bear sudden change from salt to fresh water, and to meet this argument I made an experiment with Mullet in 1879. I took a dozen or more medium-sized Mullet from the warm shoal water of the bay and placed them in cool, fresh spring water. They swam around very rapidly for about half an hour, then sank to the bottom of the spring, where they remained, apparently comfortable, for twelve hours. Before leaving the spring I returned them to their native waters, seemingly in as good condition as when first caught. The bay water was at that time 77° Fahrenheit and the spring water 71° Fahrenheit, a difference of 6° and a change from pure salt to pure fresh water.

"After spawning, in October and November, the Mullet leave these bays in small schools, going directly to deep water if the weather is stormy, and following the beach along if there is not much surf. Those that have been in the bays all the summer leave also at about this time, many of them having spawned at the same time with the full 'run.' A few of these, having just reached maturity, are found with spawn nearly all winter; also, some young stragglers. In February, March, and April, young Mullet, varying from one to two and a half inches long, are found in great abundance along the bay shores. Mullet grow to about eight inches in length the first year, to twelve or thirteen inches the second year, when they are mature. The average size of adults is twelve inches in length, weight about one and a quarter pounds. The largest I have seen measured twenty inches long and weighed four and a half pounds. It was caught at Charlotte Harbor, Florida. Mullet of that size are extremely rare in West Florida. Those of South Florida are much larger, as a rule, than those found farther north. There they are also far more abundant than on the coasts of West Florida, Alabama, Mississippi, Louisiana, and Texas.

"In October, Charlotte Harbor, Sarasota and Palmasola Bays, seem to be the headquarters of all the Mullet of the Gulf. Tampa Bay, Anclote River, Homosassa River and vicinity, are also favorite spawning places. During the fall they move in such immense schools that the noise of their splashing in the water resembles distant thunder; and to persons living near the river or bay, their noise, kept up day and night, becomes very annoying. These schools are followed by large numbers of sharks, porpoises, and other destructive fishes, as well as pelicans and like sea-birds, all of which eat of the Mullet until they can eat no more, and have to make way for fresh arrivals. In spite of these enemies and those of the eggs and fry, Mullet are as plentiful as formerly, according to the general opinion of the fishermen of the coast.

"The Mullet is a bottom-feeding fish, prefers still, shoal water with grassy and sandy bottom. It swims along the bottom, head down, now and then taking a mouthful of earth, which is partially culled over in the mouth, the microscopic particles of animal matter or vegetable matter retained, and the refuse expelled. When one fish finds a spot rich in their desired food, its companions immediately flock around in a manner that reminds one of barn-yard fowls feeding from one dish. The Mullet eats very little compared with other fish of its size. It preys on no

other fish, and is preyed upon by nearly all other common fishes larger than itself. It does not readily take the hook, but can sometimes be caught with a bait of banana, or one manufactured from cotton and flour. It is the most widely distributed fish of the Gulf of Mexico, being found on the sea-beach everywhere, in all the bays and sounds, and even far up fresh-water rivers and in fresh-water lakes that have outlets."

Concerning the other species of Mullet, *Mugil brasiliensis*, as occurring in the Gulf, Mr. Stearns writes:

"It is common, and is found in company with the *Mugil albula* and usually considered with it, and the old fishermen of Pensacola distinguished it and have given it the above name. I have found spawn in them in May and June. On the southern coast they are very abundant, and appear in Key West almost daily in the fall and winter."

MULLET IN CALIFORNIA.—"On the California coast occurs *Mugil albula*," writes Professor Jordan, "which is commonly known as the 'Mullet.' It reaches a length of about fifteen inches. It is very abundant about San Diego, and thence south to Mazatlan, and it ranges occasionally northward as far as Monterey. It enters creeks and lagoons, ascending as far as the brackish water extends, in the winter, and thus is often land-locked in great numbers, which are then destroyed by the sea-birds, especially by the pelicans, and a few are taken in seines. It swims in schools in the bays, and its presence is made known by its frequent leaps from the water. It is said that the Mullet has long been known at San Diego, but that it first made its appearance at San Pedro in 1877. It is not well known either at Santa Barbara or Soquel, although now occasionally taken at both places. Those fishermen who have given the matter any attention assert that the Mullet is gradually extending its range northward. It feeds on mud and minute organisms contained in it. It is considered a good food-fish when taken from the ocean. In the muddy lagoons it acquires in summer a rank flavor."

154. THE SAND SMELTS OR SILVER SIDES—ATHERINIDÆ.

The "Sand Smelts" or "Silver Sides" are small carnivorous fishes which occur everywhere along the coasts of temperate and tropical regions. They are found in almost countless numbers in brackish water and at the mouths of rivers, living, for the most part, within a few yards of the shore, where they prey upon other small fish, upon crustaceans, and upon refuse organic matter, and are in their turn the prey of other fish, particularly the young of the larger fishes of prey which create so much havoc farther out at sea; for instance, young bluefish, squeteague, and mackerel. In general appearance they resemble the smelt, and at various places are called "Sand Smelts" and "Green Smelts." They may be readily distinguished from the true smelt by the absence of the adipose second dorsal fin, which occurs in all members of the salmon tribe, and by the presence of the small spinous dorsal. The most important species on the Atlantic side is the Green Smelt of the Connecticut coast, *Menidia notata*, also called in some parts of New England the "Friar," by the boys about Boston the "Capelin," about New York the "Sand Smelt" and "Anchovy," and about Watch Hill the "Merit-fish." In Beaufort Harbor, according to Jordan, two other species of the genus are very abundant in company with a species of *Engraulis*, and are known as "Sardines."

The range of this species extends from Maine at least to North Carolina. They spawn all along our sandy shores, where at any time in summer tens of thousands of them may be gathered in an hour with a small seine. In the shallow sandy bays the young fish, about an inch in length, were found in schools, while in more exposed localities, such as the Napeague Harbor, Watch Hill Beach, and the north part of Montauk Point, the largest schools of adult fishes were found, though large individuals were also frequently found in the more protected coves. They swim in

immense schools, generally those of the same size together; they vary in length from half an inch to seven inches. They apparently breed throughout the hot season. Individuals two and a half inches long, taken in the Little Harbor, Wood's Holl, Massachusetts, July 2, 1875, were full of ripe spawn and milt which they yielded freely.

Capt. John B. Smith, of New Bedford, furnishes an interesting account of the spawning of this fish, *Menidia notata*, as witnessed by him during a visit to the head of Buzzard's Bay, on the 13th of June, 1872. He observed great numbers of the fish in the sedge grass, in the afternoon of that day, when the falling tide was about one-fourth down. The fish came in a body into shallow water, within three feet of the shore, then darted among the grass, and rolled over from one side to the other, struggling with all their strength, some of them jumping entirely out of the water while in the operation. The eggs were then to be seen fastened in sheets and in masses to the grass, like frogs' eggs in a mill-pond. These were about the size of No. 9 shot. During the operation of spawning, which lasted about a minute, the fish were very sluggish, and could readily be taken with the hand. The number of fish engaged in spawning was so great that the water was quite whitened with the milt, and the grass was so full of the eggs that they could be taken up by the handful. Eels and small fishes of various kinds were attracted there in great numbers, helping themselves to the dainty repast.

In addition to consuming great quantities of food such as has been described, it was found that they were very destructive to the eggs of other fishes. Although not generally eaten, they are finely flavored and an excellent article of food, not very greatly inferior to smelt. Uhler and Lugger are quite mistaken in their opinion that this species is the gudgeon of Maryland and Virginia, which is in fact a fresh-water fish, *Hybognathus regius*, together with one or two other species which are apparently often included under the same name.

In Florida this fish is replaced by two or three others belonging to the same family, which, though very abundant, are of no special importance except as food for other fishes.

On the California coast this family is of much greater importance, two of the species being in high favor as food. These are the so-called "California Smelt" and "Little Smelt." Of the former Jordan writes: "This species, the California Smelt, *Atherinopsis californiensis*, is everywhere known as the 'Smelt.' It reaches a length of about eighteen inches, and the average size as seen in the markets is not much below this. It ranges from Cape Mendocino to Magdalena Bay, inhabiting especially rocky bays sheltered from the waves. It occurs in great schools, and is extremely abundant. It is non-migratory. Its food consists chiefly of worms and small crustaceans. It is a fish of fine, firm flesh and good flavor, although a little dry. From its great abundance it is one of the most important food-fishes on the coast, being never absent from the markets. It is often used as bait, especially for the rock-fish."

Of the Little Smelt he writes as follows: "The Little Smelt, *Atherinops affinis*, or Petite Smelt, reaches a length of about a foot. It associates with the 'California Smelt,' being scarcely less abundant. It is, however, more often found in sheltered, sandy bays and lagoons than the other species, and is sometimes found in brackish water. As a food-fish it is equal to the California Smelt, but from its smaller size is of less value. Both species are greedily devoured by the larger predatory fishes."

155. THE STICKLEBACK FAMILY—GASTEROSTEIDÆ.

The Sticklebacks are represented on our Atlantic coast by three species: The four-spined Stickleback, *Apeltes quadracus*, which is found in brackish water from Cape Ann southward at least to New Jersey; the ten-spined Stickleback, *Gasterosteus pungitius*, associated with the preceding, and found also in fresh water; the two-spined Stickleback, *Gasterosteus aculeatus*,

occuring as far north as Newfoundland and south to New York. The latter species also occurs on the coast of California north to San Francisco. The Sticklebacks are great favorites with persons who own aquaria on account of the skillful manner in which they build their nests. The two-spined Stickleback attains a length of four or five inches. Schools of them are sometimes found swimming in the open sounds in midsummer. On the California coast, in addition to the two-spined Stickleback, there occurs another species, *G. microcephalus*, along the whole length of the coast from Southern California to Puget Sound. In Puget Sound, according to Jordan, the two-spined Stickleback is abundant, and forms an important part of the food of the salmon and trout. The stomach of *Salvelinus malma*, particularly, is often full of them. The name "Salmon-killer" is applied to them about Seattle, but whether the wounds are inflicted by their sharp spines in the stomach of the salmon is not known. Ducks catch and swallow the Stickleback, and are often killed by them. Excepting as food for other fishes they have no value, though on the Prussian coast, near Dantzig, where they abound, they are said to be used for feeding ducks, fattening pigs, and in the manufacture of oil.

156. THE SILVER GAR-FISHES—BELONIDÆ.

The family *Belonidæ* occurs in temperate and tropical waters all over the world, at least fifty species being known. Its members are easily recognized by their long, lithe bodies and by the shape of their jaws, which are prolonged into a long, slender beak, provided with numerous sharp, conical teeth.

"Swimming along the surface of the water, the Gar-pike seize with these long jaws small fish as a bird would seize them with its beak; but their gullet is narrow, so that they can swallow small fish only. They swim with an undulating motion of the body. Although they are in general active, their progress through the water is much slower than that of the mackerel, the shoals of which appear simultaneously with them on our coast. Young specimens are frequently met with in the open ocean. When they are young their jaws are not prolonged, and during the growth the lower jaw is much in advance of the upper, so that these young fishes resemble a *Hemiramphus*."[1]

The name "Gar" is said to be derived from a Saxon word meaning "needle," and in the Gulf of Mexico they are commonly known as "Needle-fish." On the Atlantic coast, however, the usual appellative is "Gar-fish." In Great Britain there are several names, such as "Sea-pike," "Mackerel-guide," "Green-bone," "Sea-needle," and "Garrick." They are also here called "Gray Pikes," but this name should be avoided in America, having been appropriated for the species of *Lepidosteus*, with bony scales, inhabiting the rivers of the South and West. The name "Sea-snipe" is said to be also occasionally in use, as well as "Bill-fish," which is also applied by our fishermen to the slender species of the sword-fish family. On our Atlantic coast are at least four species, the most common of which is *Tylosurus longirostris* which is found in Massachusetts Bay and south to the Gulf of Mexico and the northern parts of Central America, occurring also in the West Indies. This species attains a length of two feet, and ascends the rivers for great distances, having been found in the Connecticut as high as Hartford, in the Susquehanna at Columbia, and in the Potomac above Washington. They are also frequently seen in the harbors along the coast, but are rarely sufficiently abundant to be used for food. DeKay states that this species is highly prized by epicures.

Little attention has been paid to its habits by our naturalists, and we are again obliged to rely upon Mr. Stearns for our information. He writes: "It is common on all points of the Gulf coast. At present it is found at Pensacola only in the summer (about eight months), but on the more southern coast all the year. It is a surface-swimming fish that preys largely upon small fish that move in schools. It seems to be rather dull of observation, and I have often watched small

[1] Günther's "Study of Fishes," p. 620.

schools of minnows, that perhaps know the failing, elude it for a long time by huddling together directly above or below, when, if they moved to either side, the Needle-fish would be sure to see them, and they quite certain to lose some of their number. Its movements are very rapid and its aims most sure. I have seen a Needle-fish of fifteen or twenty inches length seize mullet and other fish fully one-third of its own size, which often prove more than it can manage. They are sometimes washed ashore dead, with some spiny fish that was a little too large fixed in their throats. The Needle-fish spawns in the bays in May and June. It is very seldom eaten on this coast, yet it is an excellent food-fish, which I prefer to many others."

Tylosurus hians is a species recently discovered on our coast and abundant throughout the West Indies.

Tylosurus caribbæus is a giant species, of which one or two specimens have been found at Wood's Holl, and which is common about Cuba. A species resembling that last mentioned, *Tylosurus Jonesii*, is abundant about Bermuda, and is emphatically the game fish of those islands, where it is known as the "Hound-fish." Individuals attain the length of five or six feet. They are fished for with salmon rods and artificial flies by the British officers in the garrison.

A related species, *Tylosurus vulgaris*, abounds on the coast of Northern Europe, and is usually found in company with the mackerel, ranging north to North Cape, and occurring in considerable numbers in the Baltic, but apparently not often found south of the English Channel. Great numbers are caught on the coast of Holland, where they are used for bait, and in many other parts of Europe they are said to be prized for food. The Germans prepare them by smoking or drying.

"In the autumn months," writes Buckland, "Gar-fish are very plentiful on the Cornish coast. In the autumn of 1867 scarcely two thousand were taken in the seines at Mevagissey, which fetched good prices, as they are much eaten by the Jews. One of the advantages of railway communication may be seen in the fact that before the opening of the Cornwall Railway the fishermen would not spend time by catching sea-fish, for which there was no demand, so that what were caught were used for manure. Mr. Hinkston, of Mevagissey, inclosed at one time in a seine-net one thousand at one time. They were at first thought to be mackerel, but, proving to be Gar-fish, the seine-net was opened and they were allowed to escape. That number would now command the sum of £90. In by-gone days they were not esteemed by the Cornish people as an article of food, but are now eaten with the greatest avidity."

The peculiar green color of the bones is said to prejudice many people against them. I have myself tasted the American Gar-fish and found it exceedingly palatable; and I cannot doubt that at some future time they will be highly prized by our people, as they richly deserve to be.

A species commonly known as the "Needle-fish," *Tylosurus exilis*, exists on the California coast. It reaches a length of about two and a half feet and a weight of little more than two pounds. It is found from Santa Barbara southward, and is rather common in the bays, its habits being similar to those of the Atlantic Gar-fish. It spawns in August. It feeds upon anchovies and similar fishes. It is a food-fish of good quality, but is not sufficiently common to be of much economic importance.

157. THE FLYING-FISH FAMILY—SCOMBERESOCIDÆ.

The Flying-fishes.

This group is represented on the Atlantic coast by several species, the most abundant being probably the common *Exocœtus Rondeletii*. They are usually seen quite a distance out at sea, and sometimes fly on board of passing vessels. They are considered excellent food, but are so rarely taken as to require no notice here.

Professor Jordan says: "The California Flying-fish, *Exocœtus californiensis*, known to the

Italians and Spaniards of the Pacific coast as the 'Volator,' reaches a length of eighteen inches and a weight of one and a half pounds, being one of the largest of the Flying-fishes. It is found only about Santa Barbara and the Coronados Islands, where it is excessively abundant in the summer, appearing in June and disappearing probably in September. This fish flies for a distance sometimes of nearly a quarter of a mile, usually not rising more than three or four feet. Its motions in the water are extremely rapid, and its motive power is certainly the movement of its powerful tail in the water. On rising from the water the movements of the tail are continued for *some seconds, until the whole body is out of the water. While the tail is in motion the pectorals* are in a state of very rapid vibration, and the ventrals are folded. When the action of the tail ceases, the pectorals and ventrals are spread, and, as far as we can see, held at rest. When the fish begins to fall, the tail touches the water and the motion of the pectorals recommences, and it is enabled to resume its flight, which it finally finishes by falling into the water with a splash. When on the wing it resembles a large dragon-fly. The motion is very swift; at first it is in a straight line, but this becomes deflected to a curve, the pectoral on the inner side of the arc being bent downward. It is able to some extent to turn its course to shy off from a vessel. The motion seems to have no reference to the direction of the wind; and we observed it best from the bow of a steamer off Santa Catalina Island in early morning, when both air and water were free from motion."

Two other species of *Scomberesocidæ* occur on the Pacific coast. *Hemirhamphus Rosæ*, J. & G., inhabiting San Diego and San Pedro Bays, is too small and too scarce to be of any value as a food-fish. *Scomberesox brevirostris* Peters is found from Tomales to Monterey, and is sent to market when taken. It is, however, extremely rare and only one was seen by Jordan.

The Skipjack—Scomberesox saurus.

The Skipjack, although in general appearance very dissimilar to the Flying-fish, is a member of the same family. It is quite similar in form to the silver gar-fish, *Tylosurus*, from which it differs in the long beak-like jaws, slender and flexible, and in having finlets behind the dorsal and anal fins. In England it is known as the "Skipper," "Skopster"; also in the books as the "Saury," or the "Egypt Herring," and by the Scotch as the "Gawnook."

This species is probably found in all parts of the Atlantic, although it has not yet been recorded from South America. On our coast it is abundant at times from the Gulf of Mexico to the Banks of Newfoundland. In the Eastern Atlantic it ranges from the Loffoden Isles, latitude 69°, to the Cape of Good Hope, specimens having also been observed about Saint Helena; it does not, however, occur in the Mediterranean, where it is replaced by an allied species, *Sayrus Camperii*, which is distinguished from it by the absence of the air-bladder. On the New England coast large schools are occasionally seen in autumn, and this is the only part of our Atlantic seaboard where they are of any special importance. Codfish feed upon them voraciously, and they are sometimes eaten by bluefish. Storer remarks: "Large quantities are yearly thrown upon the shore at Provincetown, but are considered worthless, while by the inhabitants of the other towns of Cape Cod it is taken in immense numbers and considered by many of them very nutritious food."

DeKay supposed New York to be the extreme limit of the southern range of this species, but it has been observed at the mouth of the Chesapeake Bay, and at Bedford, North Carolina, by Jordan.

Neill states that it is not an uncommon fish in the Frith of Forth. Numbers run up with the flood-tide in the autumn; they do not, like other fishes, retire from the shoals at the ebb of the tide, but are then found by hundreds, having their long noses stuck in the slush, and are picked up by people from Kincardine, Alloway, and other places. The fullest account of their habits is the following, from the pen of Mr. Couch:

"The Skipper is, more strictly than the gar-pike, a migratory fish, never being seen in the channel until the month of June, and it commonly departs before the end of autumn. It does not swim deep in the water, and in its harmless manners resembles the flying-fish, as well as in the persecutions it suffers from the ravenous inhabitants of the ocean. The methods it adopts to escape from their pursuit are peculiar. It is sometimes seen to rise to the surface in large schools and fly over a considerable space. But the most interesting spectacle, and that which best displays their great agility, is when they are followed by a large company of porpoises, or their still more active and oppressive enemies, the tunny and bonito. Multitudes then mount to the surface and crowd on each other as they press forward. When still more closely pursued they spring to the height of several feet, leap over each other in singular confusion, and again sink beneath. Still further urged, they mount again and rush along the surface by repeated starts for more than one hundred feet, without once dipping beneath, or scarcely seeming to touch the water. At last the pursuer springs after them, usually across their course, and again they all disappear together. Amidst such multitudes—for more than twenty thousand have been judged to be out of the water together—some must fall a prey to the enemy; but so many hunting in company, it must be long before the pursuers abandon. From inspection we could scarcely judge the fish to be capable of such flights, for the fins, though numerous, are small, and the pectoral far from large, though the angle of their articulation is well adapted to raise the fish by the direction of their motions to the surface. Its power of springing, therefore, must be chiefly ascribed to the tail and the finlets. It rarely takes bait, and when this has happened the boat has been under sail, the men fishing with a 'lash' or slice of mackerel made to imitate the living body. The Skipper has not been commonly taken since drift-fishermen began the practice of sinking their nets a fathom or two below the surface, a circumstance which marks the depth to which they swim; but before this it was usual to take them, sometimes to the amount of a few hundred, at almost evey shoot of the pilchard nets."

This description of their habits is doubtless very applicable to those of the same species in the Western Atlantic. I have frequently seen them in schools springing above the surface, but have never had an opportunity to study their movements closely. The Skipjack probably feeds, *for the most part, on soft pelagic animals, the teeth in their jaws being very minute.* Günther states that the young, having the beak is still undeveloped, are met with everywhere in the open ocean, in the Atlantic as well as in the Pacific.

The Half-beak—Hemiramphus unifasciatus.

Species of this genus are abundant all over the world, and are particularly numerous in the West Indies, where they are sometimes known by the Indian name "Balahoo." They are closely related to the Skipjack, but have the upper jaw short and the lower jaw prolonged into a long, slender beak. Our own species ranges in abundance from Cape Hatteras, through the West Indies, to Rio Janeiro; stragglers have been taken at Wood's Holl, Massachusetts, and a single specimen at Danvers, Massachusetts. Stearns writes that it is a common fish along the Florida coast, living in shoal water, and although so different in appearance is confused with the silver gar-fish, *Tylosurus*. On some parts of the coast it remains all the year; in others, only in warm weather. It swims in small schools, and it is probable that it spawns in the fall.

158. THE PIKE FAMILY.

The Pike—Esox lucius.

The Pike, *Esox lucius*, is one of the very few species of fish which is found on both sides of the Atlantic, and is equally familiar to the inland fishermen and anglers of North America, Europe,

and Northern Asia. Notwithstanding its broad distribution in the Old World, however, the genus *Esox* may be claimed by Americans as pre-eminently American, since all the known species occur in North America, while only one of them is found in Europe. The Pike—the "Hecht" of Germany; the "Brochet" of France; the "Luccio," or "Luzzo," of Italy, and the "Gädda" of Sweden—is easily distinguished from the allied species in the United States by its coloration, which is uniform brown, green, or black, with numerous elongate white blotches upon the sides. It is further distinguished from the Muskellunge, *Esox nobilior*, by the fact that the cheek in front of the fore operculum is covered with scales, while in the latter the lower half of the cheek is entirely naked.

It is sometimes known as the "Great Lake Pike." The name "Pickerel," which in England is used as a diminutive, and applicable to the young Pike, has in this country been appropriated to represent a smaller species of the same genus, *Esox reticulatus*, etc.; but our fishermen are not usually so skilled in ichthyology as to be able to distinguish infallibly between a small Pike and a large Pickerel: consequently there is frequent confusion of nomenclature, nor is this lack of precision altogether absent from the writings of our early ichthyologists.

The earliest biography of the Pike, written with reference to its American habitat, is that of Richardson, in the "Fauna Boreali Americana." He states that "by the Cree Indians it is called 'Eithinyoo-cannooshœoo.' As it takes a bait set under the ice more rapidly than any other fish of the same districts, it forms an important resource to the Indian hunter in the depth of winter, when the chase fails him. In the summer it is occasionally shot while basking in shallow waters, but, except in very urgent cases, powder and ball are of too high value in the fur countries to be thus expended. No quadruped, bird, or fish that the Pike can capture seems to be secure from its voracity, and even the spring perch is an acceptable prey to this water tyrant. The Pike rarely weighs more than twelve pounds in the northern parts of America. One specimen, taken in Lake Huron, was submitted to Cuvier's inspection, and it has also been carefully compared with English Pike without any specific differences having been detected."[1]

Richardson further remarks that the Pike was not mentioned by Fabricius as a native of Greenland, and has not been found on the islands of the Polar Sea. It has, however, been recently discovered by Dr. Bean in a collection received from the island of Kodiak, Alaska.

The Pike, almost universally despised, and generally, on account of its predacious habits, regarded by the fishermen of our Great Lakes as a pest, is in Europe considered one of the most important of game fishes. Walton devotes to it an entire chapter, concluding with directions how to "roast him when he is caught," and declaring that "when thus prepared he is 'choicely good'—too good for any but anglers or honest men." Mr. Chalmondeley-Pennell, a well-known English writer on angling, has published a work, of considerable size, entitled "The Book of the Pike."

HABITS OF THE PIKE IN EUROPE.—So few have been the observations in this country, and so much has *Esox lucius* been confused with the other species of the genus, that it seems impracticable to compile from American authorities a satisfactory account of its life history, and in default thereof is here presented a synopsis of what has been written concerning the habits of the species in Europe, by Dr. L. Wittmack, director of the Agricultural Museum of Germany. It is not probable that the habits of the fish in America differ materially from those here described: still the European investigations cannot fail to be interesting and suggestive to those who may hereafter have the opportunity to study the fish in our own Great Lakes.

The Pike occurs from Northern Asia to North America, and from Scandinavia to Italy. It appears, according to Kroyer, to be absent from the Spanish Peninsula. It is found in all parts of

[1] Fauna Boreali Americana, p. 124.

Germany, not only in the high mountain regions, but along the sea-coast of Northern Germany, and even close to the shores of the Baltic. The highest vertical distribution of the Pike occurs on the northern side of the Alps, in Tyrol, in various lakes, from that of Tristac, 2,670 feet, to that of Halden, 3,618 feet. On the south side of the Alps it occurs in certain lakes of the Tyrol, and in the Lake of Reschen, 4,637 feet, which is apparently the loftiest point of its distribution. In Switzerland, according to Tschudi, it ranges to the height of 3,398 feet."

The spawning time of the Pike, as is shown in an elaborate table presented by Wittmack, often begins in the latter part of February, and lasts, depending somewhat upon temperature and the weather, into March and April, sometimes even into May. It deposits its eggs upon water-plants, especially rushes and grasses. Examples one-third of a meter long are capable of reproducing their kind.

The predacious nature of the Pike is proverbial. It eats nearly all other kinds of fishes, sparing not even its own species, and also devours frogs, mice, rats, and even young ducks. Although it is voracious in its attacks upon its prey, it remains generally in quiet and seems to prefer quiet and slow-flowing waters rather than swift streams.

Wittmack gives a number of statements from authorities in different parts of Germany showing the annual rate of growth of the Pike, which appears to vary from two to three pounds, the maximum size attained being from forty-five to seventy pounds. He cites one instance in which, in two summers, a few individuals, liberated in a pond full of a species of carp, grew from the weight of one and three-quarters to that of about ten pounds.

BENECKE ON THE SPAWNING OF THE PIKE.—The breeding habits of the Pike are still further described as follows by Professor Benecke, of Königsberg:

"The Pike inhabits all of our waters with the exception of shallow and rapid brooks. It prefers clear, quiet water with clean bottom; is usually active at night and quiet in the daytime; lurks among plants in convenient corners, whence it rushes forth with arrow-like velocity. It lives a hermit life, only consorting in pairs during the spawning season. The pairs of fish then resort to shallow places upon meadows and banks which have been overflowed, and, rubbing violently upon each other, deposit their spawn in the midst of powerful blows of their tails. The female deposits generally about 100,000 yellowish eggs, about three millimeters in diameter, out of which in the course of fourteen days the young with their great umbilical sacs escape. The spawning time occurs in Eastern Prussia in the months of February to April, and occasionally the spawning of the first Pikes occurs before the departure of the ice. When well nourished the Pike grows very rapidly, and in the first year often reaches the length of more than a foot, and sometimes eventually the length of seven or eight feet. Only the young, rapidly growing Pikes are eatable, the old ones being dry and tasteless."

PIKE IN THE GREAT LAKES.—In his excursion around the Great Lakes for the purpose of gathering fishery statistics, Mr. Kumlien obtained the following notes upon the abundance of the Pike:

"On the western shore of Lake Michigan it appears to be resident in those portions of the lake off Racine, and is very rarely taken in gill-nets. It is, however, not known to Waukegan or Kenosha fishermen. At the west end of Lake Erie individuals are at rare intervals taken in pound-nets set in the deepest water. About Sandusky and vicinity, like the Muskellunge, they are said to be rather rare, though a few taken in winter around Put-in Bay Island are there regarded as residents of cold, deep water. Above Cleveland they are not known to the fishermen, but in the vicinity of Ashtabula considerable numbers are sometimes taken in spring—one or two hundred pounds at a haul of a pound-net. On the south shore of Lake Erie very few are taken in

pounds, and it is there thought that they keep constantly in deep water and seldom approach the shore. They are very salable and much sought after, but apparently nowhere abundant."

The common Pickerel—Esox reticulatus.

This fish is known in the North always by the name of "Pickerel"; in the Southern States it is usually the "Jack." It is found chiefly in the streams along the Atlantic coast, from Maine to Alabama, it being generally abundant, especially in clear, grassy streams and ponds. It is not found in the Lake region, nor west of the Alleghanies. It sometimes reaches a weight of seven or eight pounds, but is usually much smaller. As a food-fish its rank is rather high; its flesh is white and well flavored, but is rather dry and not very tender. It is, however, a very undesirable fish for propagation, from its inordinate voracity. They are "mere machines for the assimilation of other organisms."

The Brook Pickerels—Esox americanus and Esox umbrosus.

These two small Pickerel are very abundant, the former in the coastwise streams east of the Alleghanies, the latter in the Mississippi Basin. Neither reaches a length of much over a foot. These have, therefore, little economic value, and from their voracity are undesirable inmates of streams and ponds.

The Muskellunge—Esox nobilior.

The following facts regarding the abundance of Muskellunge, *Esox nobilior*, in the Great Lakes have been ascertained by Mr. Kumlien:

Among the islands dotting the southwestern part of Lake Superior, including the Apostle Islands, Sand, York, and Rock Islands, and others, this fish is caught in small quantities in the pound-nets. The Muskellunge is occasionally caught in the small bays indenting the shore south of Keweenaw Point as far as Huron Bay, and with it a large and much lighter-colored fish that may possibly be *Esox lucius*. This latter is not well known among the fishermen, but Mr. Edgerton says he has often noticed it, and has remarked that the general aspect was different from that of the Muskellunge. On the fishing grounds at the north end of Green Bay this is a rare fish, only half a dozen or so being taken each year. When it occurs it is found at any and at no particular point. Not a single specimen of this fish was taken by Mr. Nelson in ten years' fishing in the Cedar River district, and Mr. Everland in thirty-six years has not taken half a dozen. They are *reported of occasional occurrence in the Menomonee River, but are not found in deep nets far out* in the bay.

Lower down on the west coast of Green Bay, from Longtail Point to Peshtego Point, this fish occurs everywhere, but nowhere in abundance. A specimen was taken at Washington Island in 1866 that weighed forty-four pounds. The fishermen of this stretch of coast-line pronounce it Musk-ka-long. At Green Bay City this fish is caught frequently weighing forty pounds. It is common at this point, *i. e.* the southern end of Green Bay. Ascending the eastern shore of Green Bay as far as Saint Martin's Island the Muskellunge is very rare, being known by name only to a great many of the fishermen. Following the western shore of Lake Michigan southward from Porte des Mortes on the north as far south as Manitowoc this fish is rare. At Jacksonport two have been taken in seven years. At Two Rivers only one has ever been recorded, viz., in 1878. At Manitowoc it is less scarce, being caught sometimes in pound-nets and more frequently in the river. At Milwaukee the Muskellunge occurs in the lake but rarely; it is never caught in gill-nets. In 1868 Mr. Schultz took one in a small seine, in the old harbor, weighing one hundred pounds. This is believed by Mr. Kumlien to be a fact, having been testified to, as he says, "by so many reliable persons." He adds: "Formerly, fish of this kind weighing eighty pounds were far from rare."

On the 9th of April a fish of this species four feet in length was taken at Racine; head to operculum, ten inches; to eye, four inches; greatest circumference, twenty and one-half inches; over eye, eighteen inches; at gills, eighteen inches; weight, forty-five pounds. These fish are never here taken in the gill-nets; they are resident in the lake about Racine in winter. A very few have been known to occur at Waukegan. On the southeastern shore of Lake Michigan, including the fisheries of Saugatuck, South Haven, and Saint Joseph, this fish is reported as always being of a large size. At Ludington, farther north, only one instance of capture is on record; it is also said to be very rare at Grand Haven.

But little has been reported regarding the occurrence of the Muskellunge upon the numerous fishing grounds along the north shore of the southern peninsula of Michigan between Little Traverse Bay and Thunder Bay. It is generally rare through the Straits of Mackinaw, only about half a dozen being taken each season; and most abundant of all at Les Cheneaux Islands. Captain Coats caught one here, in 1874, weighing sixty-two pounds. These fish are rarely taken in pound-nets, and are chiefly caught with hook and line about the Les Cheneaux and Drummond Islands. Captain Dingman has caught only one in his pound-net in the past fifteen years. All caught, of which he has heard, have been large. In Thunder Bay about a dozen, on an average, are taken in twelve months. In Saginaw Bay they are taken in about the same numbers as in Thunder Bay. Here too they are always large fish. A few are taken in seines along the coast between Port aux Barques and Port Huron. A few also are taken annually in the Saint Clair River; perhaps a dozen or two altogether in this region during a year. Between Toledo and Detroit River, Lake Erie, a specimen of this fish is taken now and then in the pound-nets. When taken, it is always large. The same remark will apply to the vicinity of Toledo and Maumee Bay.[1]

MUSKELLUNGE IN LAKE ERIE.—About Locust Point a few are taken in the fall. Twenty years ago, in this region, including the fisheries of Ottawa, Port Clinton, Toussaint, and Locust Point, Musquellunge were taken weighing sixty and seventy pounds. In Sandusky Bay specimens are caught of forty-five pounds weight, and at Kelley's Island one was caught weighing fifty-seven pounds, and another sixty-two pounds.

In connection with the Huron (Ohio) fisheries, it is reported that about one hundred and fifty fish of this species were taken in seventy-five nets during the year 1879. They are here generally large, and are always taken in pairs. Three or four represent a year's catch of this fish at Vermillion, Ohio. About Black River, Lorain County, Ohio, Amherst, and Brownhelm Bay, it is very scarce, few being caught in nets; all that are taken are large. Of this fish, in connection with the Cleveland and Dover Bay fisheries, it may be said that it is very rare, and is becoming more so each year. Mr. Sadler says he took one weighing eighty pounds. The fishermen say they are always found in pairs.

The Muskellunge is taken at Conneaut at the rate of half a dozen in ten years. Only one specimen was taken in the Painesville pounds in 1879. At Fairport and Willoughby, Ohio, no mention is made of its occurrence. Erie Bay, especially at Dunkirk and Barcelona, New York, Erie, Pennsylvania, and Mills' Grove, Ohio, is famous for its Muskellunge fishing; this past season over sixty were caught, weighing from twenty to forty-five pounds. They are caught by trawling. Fancy prices are paid for them; about twenty-five cents per pound retail in the city and twelve and a half cents when shipped. More were caught during the season of 1879 than ever before.

MUSKELLUNGE IN LAKE ONTARIO.—The following notes relate to the fishery in Lake Ontario: At Oswego the fish is very rare on the American side; at Port Ontario one is occasionally caught;

[1] Mr. Fred. Alvord states that he procured a Muskellunge from Maumee Bay, in 1864, weighing eighty-five pounds.

at Cape Vincent they are common, especially in the Saint Lawrence. Nine have been brought in in one day, the smallest of which weighed thirty-two pounds. They are not now, however, so plentiful here as formerly.[1] At Chanmont very few are caught. Seven years ago one was captured here weighing sixty-five pounds. At Sacket's Harbor very few Muskellunge are caught.

159. THE MUMMICHOG FAMILY—CYPRINODONTIDÆ.

In the brackish waters along our coast and near the mouths of rivers, as well as in many of our fresh-water streams and lakes, are found members of the family *Cyprinodontidæ*. These are all small fishes, the size of adults, rarely exceeding four inches, never exceeding six or eight in the largest of them, *Fundulus majalis*. In New England they are usually known by the Indian name "Mummichog"; farther south by the name "Brook-fish" or "Killifish," a legacy from the early Dutch colonists, and in other localities, especially in the interior, less correctly known as "Minnow."

There are some twenty species in North America, none commonly used for food, but all of much more importance as food for larger fish, and frequently used for bait. The common species of the shores of the Gulf of Mexico, *Fundulus grandis*, is known at Pensacola by the name "Sac-à-lait," an unexplained French name also applied to a species of *Pomoxys* at New Orleans. The brackish-water species breed in summer, and young are found in immense schools among the eel-grass and on the sandy beaches in company with the sand smelt, *Menidia notatum*, and the allied species.

The *Cyprinodontidæ* are represented in California by *Fundulus parvipinnis* Gir., a little fish very abundant in brackish waters from Santa Barbara southward, and by *Cyprinodon californiensis* Gir., a small species once found at San Diego.

These fishes are particularly interesting to the physiologist, from the fact that many of them are viviparous, and that the anal fin of the adult male is modified into a copulatory organ. The two sexes of the species thus modified are usually very different in appearance, and might be mistaken for members of different genera. Those members of the family belonging to the genera *Cyprinodon* and *Fundulus* are carnivorous, while *Pœcilia* and *Mollienesia* feed upon mud.

The famous "Blind Fish" of the Mammoth Cave, *Amblyopsis spelæus*, and its allies, are closely allied to the *Cyprinodon*, though belonging to another family, *Amblyopsidæ*. These fish are useless economically, but are regarded as great curiosities, and often sold for considerable sums.

The Blackfish of Alaska—Dallia pectoralis, Bean.

By E. W. Nelson.

This species, known as the "E-ruang-uk" to the Eskimo of the Lower Yukon and adjoining region; "E-lo-ki-nik" to the Malemut Eskimo in Kotzebue Sound region; "Chorruy Ryba" to the Russian fur-traders; and "Blackfish" to American fur-traders, though insignificant in size, exists in such numbers in all the grass-grown, sluggish fresh-water streams and shallow lakes from the vicinity of Kotzebue Sound on the north to the mouth of the Kuskoquim River on the south, and up the Yukon to the mouth of the Tanana River, and for some distance up the Lower Kuskoquim, that it forms a very important source of food supply to the natives within these limits. In the low country between the Lower Yukon and Kuskoquim Rivers these fish exist in greatest abundance, and here, also, is found the most dense Eskimo population in Alaska. In this region alone

[1] By the north shore Indians this fish was called "Noscononge." A very old man, the first white child born on Prince Edward's Island, told Mr. McPherson that when he was a boy, fifty years ago, the name was an Indian one, and that our modern word "Muskellunge" is but a corruption of the old Indian word "Noscononge."

a population of nearly three thousand Eskimos rely upon this fish for one of their most abundant and certain sources of food supply. The fish is caught in wicker-work traps set in its haunts—a wicker-work or brush fence leading into the funnel-shaped mouth of the trap from each side. In many of the muddy streams and ponds the water fairly swarms with these "Blackfish." Every fall, especially after the ice forms, great quantities are taken and packed in grass bags holding from forty to one hundred pounds each. These bags of fish freeze into a solid mass, and are then stored either in turf-covered pits, or upon platforms erected upon four posts, and thus kept for future consumption. They are eaten either raw or boiled by the natives, and are chopped up and fed frozen to the dogs.

ECONOMIC VALUE OF THE BLACKFISH.—It is difficult to estimate the amount of these fish used annually. It is well within the limits, however, to state that during October, November, and December at least 1,500 pounds per day are taken in the roughly triangular region between the Lower Yukon and Kuskoquim Rivers. This amounts to 138,000 pounds, or 69 tons. During the remainder of the year they are fished with varying success, owing to different causes, and for this period it is fair to allow one-half the amount just mentioned, thus giving 103.5 tons for the annual estimated catch in this region. Over the remainder of the territory where this fish occurs my data are very meager, but by a rough estimate I would allow about one-half the preceding amount, or 51.7 tons, raising the entire estimated amount of these fish used to 155.2 tons per annum. I have been very cautious in making the estimate small, but I am satisfied that careful observation over this region will raise the amount to perhaps double that given.

The Vega expedition under the command of Baron Nordenskjöld obtained numerous specimens of this fish, and it has since been redescribed by Professor F. A. Schmidt, of the University of Christiana, under the name *Dallia delicatissima*. There can be little doubt that Nordenskjöld's specimens belong to the species above described.

Q.—THE SALMON TRIBE.

In Dr. Suckley's "Monograph of the Genus Salmo," printed in 1873, forty-three species of Trout and Salmon were enumerated as members of the fauna of North America. In the course of the extensive revisions of our ichthyology which have recently been made, this group has been sedulously studied. Only eighteen species are retained upon the list as amended by Professors Gill and Jordan. While the number of species has been lessened, several new genera have been proposed, and many changes in nomenclature necessitated.

According to the latest system, the old genus *Salmo*, which in the standard works on angling includes everything called by the names "Trout" and "Salmon," has been divided into groups. The first, for which the name *Salmo* is retained, includes the Atlantic Salmon and the black-spotted species of the west, the Rainbow Trout of the Pacific slope, *Salmo irideus*, the Rio Grande Trout, *S. spilurus*, with the two closely-related forms, more widely distributed through the Rocky Mountain region, and regarded as subspecies of this type, also the Steel Head of the Columbia, *S. Gairdneri*, and the common Black-spotted Trout, *S. Clarkii*, which occurs in the Upper Missouri, in Utah, in the Columbia River, and numerous other districts of the Northwest. In this same group are included the Quinnat, or California Salmon, and its allies, which will be discussed hereafter. These have been placed in the genus *Oncorhynchus*.

The second group includes the Chars, or Red-spotted Trout, and the gray-spotted species known as Salmon Trout, or Lake Trout. These are assigned to the genus *Salvelinus*.

160. THE SALMON—SALMO SALAR.[1]

"In Aquitania the River Salmon surpasseth all the fishes of the sea," wrote Pliny, eighteen hundred years ago. This was the Salmon's christening, and though nearly one hundred species of the family *Salmonidæ* are now known to naturalists, one has always stood pre-eminent, like a Scottish chieftain, needing no other name than that of his clan. The luxurious Romans prized highly the salmon streams in their Gallic and British provinces, if we may trust Pliny and Ausonius, and that this fish was well known to the early English is evinced by the many Saxon names, such as "Parr," "Peal," "Smolt," "Grilse," "Kipper," and "Baggit," given it in different stages of growth in Great Britain and America. The Normans brought over the name of Latin origin, which they applied to the perfect adult fish, ready for the banquets of the conqueror. When Cabot discovered Newfoundland, in 1497, he found Salmon in its waters, but the red men had long before this known the art of killing them with torches and wooden spears.

DISTRIBUTION.—Salmon inhabit the North Atlantic and its affluents. No one knows how far beyond the Arctic Circle they range, though their occurrence in Greenland, Iceland, Northern Scandinavia, and Middle Labrador is well established. They occur in Norway, Sweden, Denmark, entering the Baltic and the waters of Russia, and, according to some authorities, the White Sea. They abound in all the British Islands, where they are protected and fostered with great success, and are more or less plenty in France, Belgium, Holland, and Prussia, ascending the Rhine as far as Basle. The southern limit of their occurrence is in Galicia, the northwestern province of Spain,

[1] This chapter is based upon the essay on the Salmon in "The Game Fishes of North America," by G. Brown Goode, published by Charles Scribner's Sons.

in latitude 43°. "There is a river in Macedon," says Fluellen, in "King Henry the Fifth," "and there is also moreover a river at Monmouth: it is called Wye, at Monmouth; but it is out of my prains, what is the name of the other river; but 'tis all one, 'tis so like as my fingers is to my fingers, and there is salmons in both." Fluellen was in the wrong, for there are no Salmon in any part of the Mediterranean water system.

On our own side of the Atlantic, their presence in Hudson's Bay and on the arctic coast of America is doubtful, yet probable. They range far north on the eastern shores of Labrador, and in the waters of the Great Lake system up to Niagara.

Nova Scotia, New Brunswick, and Maine have many salmon rivers; New Hampshire, Massachusetts, and Connecticut, a few very good ones. The natural limit of the southward range of the Salmon appears to be in latitude 41°, near the Connecticut River, where they were once extremely abundant, but many stragglers have been taken in the Housatonic and Hudson. Much effort has been made in trying to prove that the Salmon, of which Hendrick Hudson saw "great store" in 1609, when sailing up the river which bears his name, were weak-fish, or some equally remote species. Surely weak-fish do not go up the river to the Highlands. Salmon have from time to time been seen in the Delaware, it is said, and, if this be true, it renders the story of Hudson still more credible.

ABUNDANCE.—Wonderful things are said about their abundance in colonial days. Every one has heard of the epicurean apprentices of Connecticut who would eat Salmon no oftener than twice in the week.[1] Like many other good ones, this story seems to be prehistoric, and was doubtless told of some other fish in the times when our Aryan ancestors dwelt on the plains of Central Asia. You may find it in Fuller's "Worthies of England," where it has the same archaic and indefinite flavor which is so evident now two centuries later. "Plenty of them in this country," wrote Fuller, "though not in such abundance as in Scotland, where servants (they say) indent with their masters not to be fed therewith above twice a week." There can be no doubt that one hundred years ago salmon fishery was an important food resource in Southern New England. Many Connecticut people remember hearing their grandfathers say that when they went to the river to buy shad the fishermen used to stipulate that they should also buy a specified number of Salmon. At the beginning of this century they began rapidly to diminish. Mitchill stated, in 1814, that in former days the supply to the New York market usually came from Connecticut River, but of late years from the Kennebec, covered with ice. Rev. David Dudley Field, writing in 1819, stated that Salmon had scarcely been seen in the Connecticut for fifteen or twenty years. The circumstances of their extermination in the Connecticut are well known, and the same story, names and date changed, serves equally well for other rivers.

In 1798 a corporation, known as the "Upper Locks and Canals Company," built a dam sixteen feet high at Miller's River, one hundred miles from the mouth of the Connecticut. For two or three years fish were observed in great abundance below the dam, and for perhaps ten years they continued to appear, vainly striving to reach their spawning grounds; but soon the work of extermination was complete.[2] When, in 1872, a solitary Salmon made its appearance, the Saybrook fishermen did not know what it was.

HABITS.—At least half of the Salmon's life is spent in the ocean. "He is ever bred in the fresh rivers," said Walton, "and never grows big but in the sea." "He has (like some persons of honour

[1] "The shad, bass, and Salmon more than half support the province. From the number of seines employed to catch the fish passing up the lakes one might be led to suppose that the whole must be stopped, yet in six months' time they return to the sea with such multitudes of young ones as to fill the Connecticut River for many days, and no finite being can number them."—PETERS: History of Connecticut, 1763.

[2] MITCHILL and FIELD.

and riches, which have both their winter and summer houses) this fresh water for summer and the salt water for winter to spend his life in."[1] Most of his tribe, however, are peculiarly fresh-water fishes, though several share his sea-dwelling habit, and others, like the Brook-trout, descend into salt water, when not prevented by barriers of temperature.[2] All of the family run into very shoal water, and usually to the sources of streams, to deposit their eggs, and all of them seek food and cool temperatures in the largest and deepest bodies of water accessible. I am inclined to the view that the natural habitat of the Salmon is in the fresh waters, the more so since there are so many instances—such as that of the Stormontfield Ponds in England—where it has been confined for years in lakes without apparent detriment. The "Land-locked" or "Fresh-water" Salmon, known also in the Saguenay region as "Winninish," in the Shubenacadie and other rivers of Western Nova Scotia as the "Grayling," and in different parts of Maine as "Schoodic Trout," "Sebago Trout," or "Dwarf Salmon," probably never visit salt water, finding ample food and exercise in the lakes and large rivers. In some regions in Maine and New Brunswick their access to salt water is cut off by dams, and some investigators have claimed that Land-locked Salmon did not exist there until these obstructions were built, some fifty years ago. This hypothesis, however, is not necessary, for in the Saguenay the Winninish have easy, unobstructed access to the sea. The Salmon of Lake Ontario and its tributaries are not thought to enter salt water, and there are similar instances of land-locking in the lakes of Northern Sweden. In the Maine lakes Salmon feed on minnows and other small fishes. The Salmon while it remains in the sea or in the brackish estuaries takes particular delight in feeding on crustaceans and their eggs, small shrimps, and young crabs. When in the rivers they eat but little, though they are at times eager enough for food, as testify their voracious rushes at the angler's fly-hook. The absenteeism of the Salmon is due principally to the dearth of desirable food in the rivers. The young fish stay in fresh water for one, and frequently two, years. When they pass down to the sea they weigh but a few ounces. They find congenial food and begin to grow rapidly. The broad world of ocean affords them new opportunities for adventure and self-advancement, and it is only when summoned by the duties of family life that they return within the narrow limits of the old home. When Salmon live in the lakes they prey upon minnows and other small fishes, but those of the sea delight also in small crustaceans and their eggs, to which they owe the vivid color of their flesh. The habits of successive generations become hereditary traits, and the differences in their life-histories seem to justify the claim of the Land-locked Salmon to be regarded as a variety of *Salmo salar*, though it is hardly to be distinguished except by its lesser size and some slight peculiarities in coloration. It is to be designated as *Salmo salar*, variety *sebago*. Although both originated in the same primitive stock, it is not probable that one changes to the other except after many generations, under the influence of forced changes in their environment.

REPRODUCTION.—Although, like the Trout, and unlike shad, Salmon spawn on a falling temperature, not depositing their eggs until the water is at least as cold as 50°, yet they seem to enter the rivers on a rising temperature. Yarrell remarked that English rivers issuing from large lakes afford early Salmon, while rivers swollen by melting snows in the spring months are later in their season of producing fish, and yield their supply when the lake rivers are beginning to fail. In America the Southern streams seem to yield the earliest fish. In the Connecticut they appear in April and May, in the Merrimack in May and June, in the Penobscot most abundantly in June

[1] WALTON: Compleat Angler.

[2] The notion of marking Salmon is not a new one. Walton, writing two hundred and twenty-five years ago, speaks of observations made by tying ribbons in the tails of some number of young Salmon which were taken subsequently at the same place, "which hath inclined many to think that every Salmon usually returns to the same river in which it was bred, as young pigeons taken out of the same *dove-cote* have also been observed to do."

and July, though some come as early as April, and in the Miramichi from the middle of June to October. I can only account for this seeming paradox by the theory that, while Salmon are not harmed by extreme variation of temperature, they may be averse to sudden changes, and though strongly impelled to seek the spawning grounds are prevented by the cold. I have ascertained that the cod possess very little animal warmth. The temperature of the blood of a number of individuals caught in twenty-five fathoms of water was 47° Fahrenheit, precisely that of the water at the bottom whence they were lifted. Mackerel swimming at the surface registered 59° or 60°, while the temperature of the water was 58°, thus indicating that they possess a trifling amount of animal heat. The Salmon unquestionably changes its temperature with that of the surrounding water in much the same way, and if, as is probable, rivers rising in the mountains are colder in early spring than the ocean strata frequented by the Salmon, here is a possible solution of the problem. It is stated that in the English rivers, which are always open, there are no regular seasons of ascent, the fish constantly passing in and out; indeed, Mr. Atkins thinks it pretty certain that large Salmon in prime condition are running into the Penobscot from the sea every month in the year. It is likely, also, that the warmth of the rivers is an important factor in accelerating the vegetative growth of the eggs in the ovaries of the mother fish.

The movements of the Salmon are not so intimately related to the temperature of the water as those of many other species. They are not sensitive to sudden changes, and are capable of enduring a range of at least forty-five degrees. In this they resemble less the migratory fishes than the permanent residents of our fresh waters; indeed, it is quite allowable to speak of them as resident, for a large proportion of the whole colony belonging in one river may be found in it at any season. This proportion cannot fall much below two-thirds, if we consider that the fish less than a year old would make up at least half its number, and that the breeding fish are in the rivers six or seven months after the breeding. The breeding fish remain during the season of greatest heat and greatest cold, though their stay after they have deposited their eggs is no doubt chiefly because their vitality is diminished and their circulation retarded by the falling temperature, depriving them alike of the craving for food and the power to seek it. Those which spawn early are believed to return at once to the sea; the more tardy ones often remain all winter, and are carried out by the spring freshets. Salmon eggs are not injured by freezing, and the fish are unquestionably quite as hardy. English fish-culturists claim that their Salmon will not thrive where the water is warmer than 60°, or at most 65° in the summer, but Mr. Atkins kept fish in his ponds at Bucksport, Maine, with the water at the bottom as warm as 74° at midday, the means of bottom and surface temperature for June, July, August, September, and October, 1872, being 60°.6, 65°.9, 69°.8, 59°, 50°.3, and 72°.9, 73°.1, 73°.6, 62°.2, 54°.3, respectively. In the Gaspé salmon streams, where the fish are in the perfection of activity, the temperature of the pools in July ranges from 40½° to 59°.

KELTS.—At the approach of the spawning season their trim shapes and bright colors disappear. They grow lank and misshapen, the fins grow thick and fleshy, and the skin, which becomes thick and slimy, is blotched and mottled with brown, green or blue, and vermilion or scarlet. These changes are chiefly apparent in the males, whose jaws now become curved so that they touch only at the tips, the lower one developing a large, powerful hook, which is his weapon in the savage combats with his rivals in which he at this period engages. When in this condition, and after spawning, when they retrace their course to the sea, they are known as "Kelts."

Having entered a river, they press on to its headwaters, where the earliest of them arrive two or three months before spawning time. As soon as the water is cool enough they proceed to deposit their eggs, in deep furrows which they plow up in the sandy or gravelly bottom of the stream,

usually near the verge of a rapid. European observers state that the furrows are shaped by the noses of the two parent fish, every nest being filled with eggs before the next one is made, and the first covered up by the sand which is loosened in digging the second, chiefly by the action of the current. Mr. Atkins observed a female Land-locked Salmon excavating a nest by turning on her side and flopping violently against the bottom with her tail, while the male was engaged in driving away rivals and predaceous foes. Spawning is not accomplished at once, but the eggs are deposited by installments, as fast as they mature, during a period of from five to twelve days. "When the furrow is made, the male and the female retire to a little distance, one to the one side, the other to the other side of the furrow; they then throw themselves on their sides, again come together, and rubbing together both shed their spawn into the furrow at the same time." This is the observation of Mr. Ellis on the European Salmon, and a similar habit has been observed by Mr. Whitcher in Canada. In the tributaries of the Saint Lawrence spawning begins by the middle of October; in Maine, with both Land-locked and Sea Salmon, a week or two later, and it is presumable that in the Connecticut it will be found to occur well along towards December. In Great Britain and in the Rhine the season begins in October or November, continuing in some rivers till February.

Salmon eggs are about one-quarter of an inch in diameter, and of a bright reddish or yellowish hue. English fish-culturists estimate the number of eggs yielded by a large fish at 1,000 to each pound of her weight; experiments in the Penobscot indicate a yield of not more than 5,000 or 6,000 for a fish of eight pounds, and about 15,000 for one of forty pounds. In the Scotch streams the eggs come to maturity in one hundred to one hundred and forty days, but in our colder waters, at a temperature of 33° through winter and spring, the period of incubation is supposed to extend over six or seven months, the young fish not appearing until May. In the hatching-houses the period varies greatly, eggs having been hatched in fifty-four days with a temperature of 55°, and in one hundred and fourteen at 36°.

YOUNG FISH.—The newly hatched Salmon measures about three-quarters of an inch, and has the yolk-sac adherent from four to six weeks. When this is absorbed it begins to feed, rising greedily to seize any minute floating object. At two months the fry has grown to an inch and a half, and begins to assume the vermilion spots and transverse bars or finger marks which entitle it to be called a "Parr," and which it retains while remaining in fresh water, sometimes until it is seven or eight inches long. It continues a "Parr" until the second or third spring, when, in preparation for, or perhaps in consequence of, a descent toward the sea, a uniform bright silvery coat is assumed, and the Parr becomes a "Smolt." After remaining from four to twenty-eight months in the salt water it again seeks its native river, having become either a "Grilse" or a "Salmon." The "Grilse" is the adolescent Salmon; it weighs from two to six pounds, and is more slender and graceful than the mature fish, with smaller head, thinner scales, more forked tail, and spots rounder, more numerous, and bluish rather than jetty black. The two may easily be distinguished even though both should be of the same size, as not unfrequently happens. The male Grilse is sexually mature, but not the female, in America; in Europe the same is claimed for the male Parr and the female Grilse. "There is nothing in the water," says Norris, "that surpasses a Grilse in its symmetrical beauty, its brilliancy, its agility, and its pluck. I have had one of four pounds to leap from the water ten times, and higher and farther than a Salmon. Woe to the angler who attempts, without giving line, to hold one even of three pounds; he does it at the risk of his casting line, or his agile opponent tears a piece from its jaw or snout in its desperate effort to escape."

Mr. Atkins calls attention to the fact that the great run of Grilse which is so prominent a feature in Canada and Europe is almost entirely absent in the rivers of the United States, the fish

not returning until they have become adult. In rivers where Grilse are found, the Salmon always precede them in their ascent, for they do not enter fresh water until toward the end of summer.

Who can wonder at the angler's enthusiasm over "a Salmon fresh run in love and glory from the sea?" Hear Christopher North's praise of a perfect fish: "She has literally no head; but her snout is in her shoulders. That is the beauty of a fish, high and round shoulders, short waisted, no loins, but all body and not long of terminating—the shorter still the better—in a tail sharp and pointed as Diana's, when she is crescent in the sky." Mr. Kilbourne's painting in Scribner's "Game Fishes of North America" represents a thirty-pound fish drawn to a scale of one-fourth. The largest on record was one of eighty-three pounds, brought to London in 1821; the Scotch fish rarely exceed twenty-five pounds. Perley speaks of a sixty-pounder taken long ago in the Restigouche; in 1852 many of forty, and one of forty-seven, pounds were caught in the Cascapediac. Mr. Frederick Curtis' score for York River, Canada, July 7, 1871, shows nine fish ranging from seventeen to thirty-four and averaging twenty-six and a quarter pounds. Another, for the same locality, July, 1876, shows one hundred and ten fish, averaging more than twenty-two pounds. This was by Mr. Thomas Reynolds, who caught in the same river a fish of forty-seven pounds, the largest ever killed in Gaspé with a fly. In the Penobscot forty-pounders have occasionally been taken, but not more than one out of a thousand weighs thirty, and the common size is from ten to twelve pounds. A fish two feet long would weigh about six pounds; one of thirty inches, nine or ten; one of three feet, sixteen to seventeen; and one four feet long, nearly fifty. A score of twenty-two days' fishing, with four rods, in the Godbout, in June and July, 1865, foots up four hundred and seventy-eight fish, averaging nine and three-quarters pounds.[1]

SALMON IN LAKE ONTARIO.—The following notes by Mr. Kumlien on Salmon in Lake Ontario possess much interest: "At Oswego they were formerly very abundant and very important; they used to go up the river (Oswego) to the falls. In the last eighteen years they have gradually decreased till now they are caught only as stragglers. Forty have been speared by one man in a day. Navigation and various kinds of mill refuse have driven them away. A few years after the dams were built they yet came in abundance, and tons of them were speared from the dams, but they have gradually grown less till now only an occasional straggler is caught.

"At Port Ontario," Mr. Harrington says, "in 1879 only a very few were caught in the seines. For the last three or four years have been scarce in the river. I think it is because the mills and factories—especially the book-board mill at Pulaski—throw the refuse into the river. They have not been plenty in the river as far up as Pulaski since 1875. It is currently reported that considerable numbers were caught in the river five or six years ago, and disposed of on the sly. They seem to have turned their course from this river. Of late years a few weighing eighteen to twenty pounds have been taken; we used to consider twelve pounds an average. Some weighing thirty pounds have been taken."

"At Pulaski, Mr. J. A. Mathewson & Bro. (Mathewson has fished here the last fifty-five years) report as follows on the salmon fisheries: "In October, 1836, two men took two hundred and thirty Salmon between 8 p. m. and 12, with spears and fire-jacks, and after 12 till morning two other men in the same skiff took two hundred odd, the average weight of the entire lot being fourteen and three-quarters pounds. We have had fifteen hundred fresh Salmon in the fish-house at one time. When a freshet occured in June a few would always come up, and sometimes a few early in the spring. Any time from June till winter when there was a freshet they were sure to come. The principal time, however, was in fall, during September, October, and November. Twelve skiffs in one night

[1] NORRIS: American Angler, p. 117.

have taken an average of three hundred Salmon each. For the last twenty years the catch has been nothing to what it used to be, though some are taken even now. The gill-nets stretched across the mouth of river assisted to a large extent in causing the decrease. The fish used to run up to the falls, ten miles above Pulaski; now there are two dams in the way. They never could go above the falls, as they are one hundred and eight feet in perpendicular height. I think the mills (factories), tanneries, etc., are prolific causes of the disappearance of Salmon. Lime is one of the worst things thrown into the river; vats of refuse lime have been emptied when the river was full of fish, and upon the next they were gone. Lime, tan-bark, sawdust, and gill-nets have driven the Salmon from our river.

"There were formerly three salmon streams in this vicinity—Grindstone Creek, Deer Creek, and Salmon River—and each stream had a different type of fish. An experienced fisherman could readily tell from which stream a fish was caught, though they are but four miles apart. In Deer Creek the fish were long and slim, in Grindstone short and chubby, and in Salmon River large and heavy.

"The largest specimen ever caught here weighed forty-four and three-quarters pounds. Some have been taken as small as one pound. A few will come up now as soon as there is a freshet. There is a fish-way here on the lower dam, but its construction is so defective that very few if any of the fish are able to get over it; they were seen to try last fall and fail. They are caught (and always were) with a large three-tined spear from a skiff with a jack-lantern. Two thousand have been landed at the bridge in one night."

"Mr. Cross says: 'They often went over the dam before the apron was put in, but now they must jump along a twenty-foot apron besides the height of the dam (eight feet). The way it is now, a few manage to get as far as the first pocket and then fall back again. Forty years ago the salmon fisheries on this river brought more money to the people than all the machinery now on the river.'

"At Cape Vincent they were formerly taken on the lake shore during the migrations. Never went up the Chaumont Bay. No rivers here to spawn in. Never seemed abundant in the Saint Lawrence only as they passed by. Even now one is occasionally taken in the gill-nets in the lake.—(McPherson.)

"At Chaumont four were caught in 1879; were formerly common during their migrations.—(Dewy.)

"At Sacket's Harbor very rarely taken now; used to get them at Phillips Point as they were passing by."—(Clark.)

161. THE SALMONS OF THE PACIFIC.

By David S. Jordan.

The Steel-head—Salmo Gairdneri.

This species is everywhere known as the "Steel-head." The name "Hard-head" is sometimes applied to it, and it is known to the Russians as "Seomga." The name "Mykiss" is said to have been formerly applied to it in Kamtchatka. Large individuals are often called "Salmon Trout." The Indian name "Humaăna" is said to be given to it on the Upper Columbia. It reaches a weight of twenty-two pounds, the average weight when fully grown being about sixteen. Young specimens are very scarce in our experience. It is found from Monterey to Kamtschatka, always close to the coast. In the Columbia and Frazer Rivers it occurs in abundance in the spring at the time of the salmon run. None have yet been noticed to the eastward of the Cascade Range,

and so far as appearances go it is a permanent inhabitant of river mouths. It probably spawns late in the fall or in the winter, as many of those taken at the first run of the Salmon are spent fish, with the flesh white and worthless.

The history of this species is still obscure. According to Pallas, it migrates singly, from June to September; some remaining all the year in the rivers, returning to the sea in May. It feeds in the fresh waters on any living thing. Hence, unlike the other Trout, which during the ascent of the rivers grow lean with fasting, breeding, and exertion, this species is plump and well fed, and, with *Salvelinus malma* only, does not perish in the winter. Elsewhere than in the Columbia this species is highly valued as a food-fish. When taken in the Columbia in spring little or no use is made of it. Its flesh is pale, and its bones too firm for it to be used in canning, and at that season the old individuals taken are usually spent and worthless. In the Sacramento it is not very common.

The Rainbow Trout—Salmo irideus.

This species is generally known as the "Brook Trout," "Mountain Trout," "Speckled Trout," "Golden Trout," and other evanescent names are also sometimes applied to it. It does not reach a weight of more than five or six pounds, so far as we know, and most of them as taken are fingerlings ranging from four inches to a foot in length. It is found throughout California in all streams of the mountains. It is said to occur in the northern part of Lower California. The southernmost seen by us were from San Luis Rey River. We have seen but few specimens of this species from salt water. These weighed from three to five pounds each. It may probably run into the sea from streams in which the lower waters are clear. Specimens referred to this species from the north of Mount Shasta are perhaps the young of *S. Gairdneri*. It feeds on worms, larvæ, and the like. For a Trout, it is a fish of little "gaminess" or activity. It is not often brought into the markets of San Francisco, and at present has little economic importance, although of course a good table-fish. It has been rather extensively introduced into the waters of the Eastern United States.

The Black spotted Trout—Salmo purpuratus.

This fish is known as the "Trout," "Mountain Trout," "Spotted Trout," "Black Trout," "Silver Trout," etc., in the mountains, but when in the ocean, full grown, as "Salmon Trout" or "Steel-head." The Indian name "Preestl" is also ascribed to it on the Upper Columbia. It reaches a weight of thirty pounds under the most favorable circumstances, but may be found in any stream or lake of any length from two inches up to two or three feet. Unlike *S. Gairdneri*, the young are very common, and it probably begins breeding in mountain streams at a length of less than a foot. It is universally distributed through the Rocky Mountain region, chiefly east of the Sierra southward, but reaching the sea from Mount Shasta northward. It occurs in every lake of New Mexico, Utah, Western Colorado, Wyoming, Montana, Idaho, Oregon, and Washington. Every stream throughout the most of this region abounds in them, and in Puget Sound the young of every size occur in the salt water in abundance. Individuals are occasionally taken along the California coast. Local variations occur in abundance. Specimens from Seattle have the scales notably larger than those from Victoria and Astoria, which agree with Utah Lake specimens in this respect. Those that live in the depths of shady lakes are almost black, while others are pale. Those in the sea are silvery and only faintly spotted. Only in Lake Tahoe do the variations assume any marked importance (var. *Henshawi*). Individuals intermediate between this species and *S. Gairdneri* are not rare, and there is no doubt that the latter is simply an offshoot from this general stock, as are *S. irideus* and *S. stomias*. It feeds on any living thing it finds near it. In the

mountain lakes it spawns in the spring, running into the rivers for that purpose. Its great enemies at that season are the various species of suckers and chubs, which feed, the former upon its eggs, the latter upon the young Trout. So very destructive are the former in many trout lakes, as Utah Lake, that the destruction or diminution of the suckers ought to be accomplished by law.

A parasitic tape-worm, *Dibothrium cordiceps*, Leidy, is said to frequently infest this species, so as to render its flesh uneatable in the summer, in the Yellowstone Lakes. (Yarrow.)

As a food-fish this Trout is excellent. Large numbers of the variety *Henshawi* are shipped to the market of San Francisco. Attempts have been made to cultivate it in parts of California, I believe with success. A small hatchery has been established at Tahoe City for the purpose of keeping stocked a small branch of the lake in which summer visitors may fish.

In the opinion of the writer this species is likely to prove much more valuable for introduction into Eastern waters than the Rainbow Trout. It is more active, more gamy, reaches a larger size, and thrives in a greater variety of waters.

The Rio Grande Trout—Salmo spilurus.

This species is abundant in the headwaters of the Rio Grande, Rio Colorado, and their tributaries, being the finest food-fish in New Mexico and Western Colorado. It has also been taken in Bear River, and probably is found in most of the mountain streams of Utah, being in general rather southern in its distribution. It probably inhabits all streams within the circle of its distribution, without regard to the direction in which they may flow. We have not seen this species in life, and little distinctive is known of its habits. It is probably a comparatively recent offshoot from *S. purpuratus*. As in other species, considerable variation is shown in specimens from different localities. Its usual size is larger than that of *S. purpuratus*.

The Dog Salmon—Oncorhynchus keta.

This species, during the period of its run in the fall, generally goes by the name of "Dog Salmon," under which name the males of the Silver Salmon, and even of the Quinnat, are often confounded with it. The Russians now, as in the time of Pennant, Pallas, and Walbaum, call it "Kayko," the name "Keta" (whale) being no longer in use. On Frazer River the name (Musquam) is now "Qualoch," at Seattle (Nisqually) "Ktla-why," and in the Chinook jargon "Le-Kai." This species is very uniform in its size, and averages ten to twelve pounds. It ranges from the Sacramento River to Bering Strait, where it seems to be especially abundant; it being the only Salmon brought from there in a recent cruise of the revenue-cutter Corwin. It is seldom or never seen in the rivers in spring.

The Hump-backed Salmon—Oncorhynchus gorbuscha (Walb.) Gill & Jor.

This species is known to the Russians still, as in the time of Pennant and Pallas, by the name of "Gorbuscha," *gorb* meaning hump. The English-speaking people call it generally the "Hump-back Salmon," and often the "Dog Salmon." On Frazer River it is known as "Holia" or "Hone" Salmon, and on Puget Sound as the "Haddoh." This is one of the smallest Salmon, not averaging over four or five pounds, and probably never exceeding ten. It ranges from the Sacramento River to Alaska and Kamtchatka. In the Sacramento and Columbia it is only an estray, on the latter river being sometimes called "Lost Salmon." In Puget Sound it runs in large numbers in late summer and fall, like the *Keta* or Dog Salmon, ascending every little stream. Its run in Puget Sound takes place on alternate years, a fact which seems to be well established. It was very plenty in 1879. None were noticed in 1880, but stragglers are occasionally taken during the year of

scarcity. A few were seen by us on the Columbia and Sacramento. We are told that this species runs every year in Alaska. During its run in Puget Sound the females are canned, and the males are thrown away or given to the Indians. The flesh is then pale, and the canned product is inferior in quality. In economic value the Hump-back Salmon is far inferior to the Quinnat, the Blue-back, and the Silver Salmon, and, like the Dog Salmon, is mainly useful in furnishing a winter supply of food to the Indians.

The Silver Salmon—Oncorhynchus kisutch.

This species is almost everywhere known by the name of "Silver Salmon." It has also a series of local names. In Kamtchatka it is still known by the name "Kisutch," in use in Pennant's time, a hundred years ago. The name "Bielaya Ryba," or "White-fish," is also ascribed to it. On Frazer River it is known by the Musquam name of "Coho"; at Seattle, by the Nisqually name of "Skowitz"; about Cape Flattery by the Makah name of "Hoopid"; on the Columbia it is called "Silver Salmon" or "White Salmon," and southward the same names prevail. It reaches a weight of twenty pounds, the usual range being from seven to ten. The Silver Salmon enters all the rivers from the Sacramento to Kamtchatka. In the fall it is abundant in probably all the rivers. Few or none, however, are seen in the spring. They are often taken with seines in Puget Sound at all seasons. Like the other fall-running Salmon, it seldom ascends the rivers to any great distance.

The Blue-back Salmon—Oncorhynchus nerka.

This species is known as the "Red-fish" to the English-speaking inhabitants of Alaska and Kamtchatka, and to the Russians, now as in the time of Pennant and Pallas, as "Krasnaya Ryba," which signifies *red-fish*, the name having reference to the color of the flesh. It is not unlikely that other species are occasionally confounded under this name, but there is little doubt that the present species is the one to which it is chiefly applied. On Frazer River, where this species is the most important Salmon, it is known as the "Suk-kegh." Elsewhere in Puget Sound it is rarely seen. In the Lower Columbia it is known by the appropriate name of "Blue-back"; in the Upper Columbia as "Red-fish." Its average weight does not exceed eight pounds, and its extreme weight is probably not above fifteen. Its range is from the Columbia River to Japan and Kamtchatka. It runs in considerable numbers in the Columbia, and in much greater abundance in Frazer River, where it is the principal spring Salmon. We have no information as to its occurrence in California, or as to its entrance into any of the streams south of the Columbia. Like the Quinnat Salmon, it is attracted in early spring into all those streams which are fed by the melting snows, and into no others. Its run in spring on the Columbia is, so far as we know, contemporaneous with that of the Quinnat Salmon. The numbers are, however, much less, and I think that its run is over earlier in the fall. On Frazer River it runs with the Quinnat, or a little earlier in the spring, the run mostly ceasing in midsummer, while that of the Quinnat continues on through the fall months. This species and the Quinnat run early and go far up the streams, where, after spawning, they all die. In Puget Sound this species is not known to the fishermen, only stray individuals being taken there. It does not accompany the Silver Salmon and Dog Salmon in their ascent of the Dwamish, Puyallup, and other small streams; neither is it caught near the shore when out of the spawning season, as the other species are. In Alaska and Kamtchatka we are told that the Red-fish (*nerka*) and King Salmon (*chawytcha*) run in spring and early summer, while the other species run in late summer and fall, the Silver Salmon last.

The Blue-back is the most graceful of the Salmons and the most elegant in color. Its flesh is very similar to that of the Quinnat, but less firm and more watery, and it is not quite so rich when

canned. Next to the Quinnat, it is the most valuable of the different species, and its inferiority is mainly that of size. At the canneries four Blue-backs are taken as one Quinnat. A very few of the Columbia River canneries refuse this species, in order to be able to say that they can the Chinnook Salmon only.

BENDIRE ON THE RED-FISH.—This is the Red-fish of Idaho, the identity of which was first determined by Capt. Charles Bendire, United States Army, whose field-notes upon its appearance and habits, published in the Proceedings of the National Museum,[1] are here reproduced:

"The females are much more uniformly colored. The head is considerably tinged with steel blue, and the red tint on the sides is more or less clouded with blue and bronze. Females after spawning show considerable amount of red, only after spawning I noticed that the red coloring matter deposited in the skin appears to be drawn from the flesh, and I find that in proportion to the bright coloring of the skin of the fish the flesh loses this tint. In some instances it is barely pink-colored or almost white. After the spawning of these fish they are brightest outside and palest inside (as far as the flesh is concerned). The average size of a number of males by actual weight is only five pounds, and of females only three and three-quarters pounds. After death, within half an hour the color of these fish rapidly changes about the head and becomes a dark olive green with bluish reflections, in some instances almost bluish-black. Among any number of fish there is almost an endless variation in color, caused, perhaps, by some remaining a longer time in the lake than others. Wallowa Lake is about four and one-quarter miles in length by one and a half to two miles wide. It deepens very rapidly out a few feet from the shore, and is said to be four hundred feet deep, and more than that in places. Two small streams flow into the lake, and these form the spawning ground proper for these fish; and as there are falls about two miles above the mouth of these streams over which the fish cannot leap, they are restricted to rather limited quarters for spawning. The only place I saw any of these fish was on the bar near the head of the lake, and there most of them are caught. They can be seen in schools of one hundred or more at almost any time during the month of August and later. This year the run has been very light, and fishing had to a great extent stopped when I arrived at the lake on the last day of August. Four fisheries had been in operation, and these had put up about twenty thousand pounds of fish. I believe two or three years ago it had been the practice to obstruct the entrances to the small streams at the head of the lake to prevent the fish from running up these streams. This year this was not done, and a number of the settlers about the lake seem to be anxious to have the fish properly protected, and it is not at all too soon to do it, either. The placing of obstructions in the above-mentioned streams, and perhaps this year of gill-nets on the bar, has no doubt something to do with the scarcity of these fish. But the most abominable things of all which I saw personally in use are several clusters of hooks tied together, so that they form a circle with a radius of about three inches. Just above these hooks a lump of Red-fish eggs is laid. These are covered with mosquito-netting, and by this contrivance thousands of young Red-fish (the settlers call them "Shiners," others call them "Trout," but I am satisfied that it will be found that they are yearling Red-fish)[2] are caught and salted as well as the full-grown ones. Now, these fish are only about four inches long, and for every one caught two are crippled and die. So it can readily be seen that an immense number are destroyed yearly, as some parties make it a business to salt these down as well as mature fish.

"I examined all these modes of fishing, and when I hooked with a single hook about one out of three in some other part of the body than the head, it can readily be understood how murderous

[1] Vol. iv, pp. 82-84.

[2] No doubt of it.—D. S. J.

such a contrivance as the above must be, and how many young fish can be destroyed by a single person in a day. They bait them first, and when they become plenty use their grappling hooks.

"The fishermen at the lake complain that the Indians destroy the fish, but from personal observation I can't at all agree with them. It is true that numbers of Indians come from various parts of the country to Wallowa Lake yearly to fish, and they catch a good many. While I was camped at the lake I examined the catch of every Indian that passed my camp, and I looked at as many as fifty Indians a day; each one had from six to twelve fish usually tied on his horse, and I found that there was about one female to ten males, and most of these were spent fish which had already spawned. They are not at all particular about this, and a fish which may be all bruised up and skinned is apparently just as well relished by them as a perfectly sound one, and even these Indians appreciated the fact that it would not do to catch too many females; at any rate they told me that as a rule they let the females go, and this is a good deal more than most of our white fishermen are willing to do. Mostly every one out here now concedes that the Red-fish is not a resident of the lakes wherein it is found, and I am perfectly satisfied that they are anadromous and not land-locked. The only thing as yet which I can't understand is, how do they get rid of the hooked nose and the hump after going back to salt water? They surely can't all die after spawning, and sometimes one that weighs as much as ten pounds is caught, and this fish is certainly older than a five-pounder; and it would not be presuming too much to assert that a Salmon of that size must have made more than one trip to sea. While in the lake they do not appear to eat anything, and the stomachs of several which I examined were entirely empty. I cannot understand how they get rid of their long hooked nose and hump."

162. THE QUINNAT OR CALIFORNIA SALMON—ONCORHYNCHUS CHOUICHA.

By Livingston Stone.

"In Alaska and Kamtchatka," writes Jordan, "this species is known as the 'King Salmon,' and as 'Choweecha' or 'Tchawytcha,' a name easier to pronounce than to spell, to the Russians. In Frazer River it is called by the Musquam name of 'Sah-Kwey'; in Puget Sound it is called the 'Columbia River Salmon,' or in the Chinook jargon 'Tyee.' On the Columbia River the name 'Chinook Salmon' is in universal use. Farther south the name 'Salmon' is applied to this species, while the others receive specially distinctive names. The Quinnat Salmon reaches a weight of sixty to ninety pounds, being the largest of the salmon family. The average weight is, however, much less. On the Columbia River the average is twenty-two pounds each; on the Sacramento River, about sixteen. It is probable that the individuals of about twenty pounds' weight are four years old, and the larger ones occasionally taken are older, having probably lived through one or more spawning seasons. Those which enter the river late in the fall cannot ascend far before the necessity for spawning comes, and such may be able to return to the sea, and thus escape the death which overtakes all that spawn far inland.

"In all streams having their rise in the snows this species begins running as early as March, and the run continues with various interruptions until the spawning time in the fall. When a freshet occurs in spring, the run for a time after is much increased. In regard to this species and the 'Blue-back,' it would appear that they, when adult, enter the streams whenever cold fresh water comes in contact with them in the sea. After entering fresh water they do not feed, and they continue their ascent until the season for spawning actually overtakes them. Often they ascend hundreds of miles, until they are almost worn out, and after the spawning act all that have thus ascended die. Those streams which do not have their source in the melting snows have no spring run of Salmon, and in them the Quinnat runs only after the fall rains have set in.

"The distribution of the Quinnat is from Ventura River, where individuals occasionally run in the winter, to Kamtchatka. It also occurs in the rivers of the corresponding latitude in Asia The abundance of this species has probably not yet materially diminished in the Columbia. More than a million and a half have been canned on the Lower Columbia during the present season (April, May, June, July, 1880), a greater number than has ever been taken before. In the Sacramento the numbers have doubtless been reduced by overfishing, and a systematic process of keeping up the supply in the Columbia by means of hatcheries will very soon be necessary.

"The Salmon take no food in fresh water. In the headwaters of the rivers, in the clear water, they (at least the males) will sometimes take an artificial fly. In the ocean they take a trolling bait readily. They then feed on anchovies, herring, smelts, sand launces, shrimps, and in general on any living object. Even at the time of first entering the rivers in spring the stomach is found empty and contracted.

"The enemies of the Salmon are, when very young, the chubs, suckers, and other small fishes, which prey upon the eggs and young fish. In the ocean their chief enemies are the seals of different species, who bite out their throats and destroy very great numbers of them all along the coast. No diseases were noticed by us, except those produced by the accidents and great exertions accompanying the spawning season.

"The economic value of this species at present exceeds that of all others on the Pacific coast combined. It is brought fresh to the markets of all the cities, and the flesh is canned for export to the East and to other countries, especially to England."

NAMES.—The first scientific name by which this fish was commonly known was *Salmo quinnat*. This name is generally reputed to be derived from a river, called the Quinnault, where a particularly good variety of this Salmon was found. This the writer is quite positive is an error. The common name of the Salmon, at least among the Columbia River Indians that lived near the mouth of the Willamette, was "Quinnault," of which *Quinnat* is a corruption, and the scientific name was undoubtedly taken directly from the Indian name of the fish. The river might have been named after the fish, but it is not likely that the fish was named after the river.

Not long ago Professor Jordan, after a critical examination of the fish, pronounced it to be not correctly a Salmon, but an *Oncorhynchus*, and rechristened the fish *Oncorhynchus quinnat*, which name it held till last summer (1880), when Professor Jordan discovered that the fish had probably been described by Walbaum, in 1792, under the name of *Salmo chouicha*, and yielding to prior authority restored its original name, by calling it *Oncorhynchus chouicha*, which name it will now probably retain until a more captivating successor presents itself. The small fish which were called by Girard, Suckley, Jordan, and Copeland by the appellations *Fario argyreus*, *Salmo argyreus*, and *Salmo Warreni* were without doubt the young of the *Oncorhynchus chouicha*, and the names will now be given up.

DISTRIBUTION.—The distribution of this Salmon is quite limited, being at present restricted to the Pacific slope of North America, between the neighborhood of the bay of Monterey and the Alaska border, although if it is the same as the "King Salmon" of the Yukon and the Alaska Rivers its range extends as far north as the Arctic Ocean.

The California Salmon is taken in the largest quantities in the Sacramento and Columbia Rivers, these being the largest rivers on the coast, but is also found in considerable numbers in the smaller rivers of California, Oregon, Washington Territory, and British Columbia, notably in the Eel, Russian, Klamath, Rogue, and Frazer Rivers.

The adult fish vary widely in size. The smallest mature fish on record was caught in the McCloud River, California, and weighed about four pounds. The largest on record was caught in

the Columbia River, and weighed eighty-three pounds. The writer has seen one on the Columbia that weighed sixty-seven pounds.

The California Salmon is easily caught with hook and line in the fresh-water tributaries, where it goes to deposit its eggs. It does not readily take a fly, but becomes an easy victim when tempted with salmon roe, which is the most effective of all baits for catching this fish. When prime it very much resembles in appearance the well-known Atlantic Salmon (*Salmo salar*) in the same condition, with this exception, that it has on its back and sides nearly black, star-like spots, while the Atlantic Salmon has none, when fresh from the ocean.

The California Salmon is a remarkable fish, and has had an extraordinary career. Fifty years ago it was hardly known, except to students of natural history. Now it is known and eaten almost all over the world, for there is hardly a port in the world where ships have not carried the canned Salmon of the Columbia, which is the same fish under a different name; and not only has this fish, in the form of food, traveled nearly all over the world, but the living embryos of the California Salmon have been transported to England, France, Germany, Belgium, Denmark, Russia, Australia, and New Zealand, so that there is probably no one fish inhabiting a limited locality which is known over the world in so many different places as the California Salmon.

This magnificent fish is deserving of its career. If splendid proportions, of unsurpassed vigor and spirit, it has no equal in external attractiveness among the race of fishes, except its own cousins of the Atlantic and other oceans, while as regards the quality of its flesh and its marvelous abundance in its habitat, it has but few equals in the world. As to the quality of its flesh, it closely resembles the highly-prized Salmon, *Salmo salar*, of Great Britain and the Atlantic coast of North America, which has no superior, and as to its abundance I need only say that nearly two hundred million pounds have been caught in the Columbia River alone during the last six years, without producing, according to the most recent testimony of the Columbia fishermen, any serious diminution of the river's stock.

DEVELOPMENT.—The Salmon begins life as a bird does, in an egg. When the egg first leaves the parent fish it is about one-fourth of an inch in diameter and of an orange tint. In a few days there can be seen in the egg a fine dark line, which is the first visible beginning of the future salmon. In nineteen days, in water at 55° Fahrenheit, the black pigment of the eye begins to show through the translucent shell. In thirty-five days in the same water the young Salmon is hatched. When it first emerges from the shell it is about an inch long, and carries under its body in a little round sac the yolk of the egg it came from, on which it lives by absorption for about a month longer, till its mouth is sufficiently completed to take food and its other organs to dispose of the food it takes. When it first hatches it is a clumsy-looking and an awkwardly-moving object, being about as graceful and efficient in its attempts to swim like a fish as a human beginner's attempts are to ride a bicycle. After it has lived in its sac a week or two it develops a disposition to dive and hide under something, which it does with a pertinacity which is both characteristic of the full-grown Salmon and prophetic of the tenacity of purpose it will show in ascending its breeding rivers to spawn. This irresistible instinct to dive and hide takes it still deeper under the gravel and rocks in the bed of the river which formed its birth-place, and it stays here in the crevices of the rocks and gravel, as snug as possible, until the sac of food which nature started it in life with is gone, and it is obliged to work for a living or starve. It would not be safe for the little helpless creature now to venture out of the rocks and gravel where it was born, for it would undoubtedly pay for its rashness by becoming food, while yet alone, for the larger fishes above. So like the early Christians in the catacombs, it spends a large portion, if not all, of its earlier life in or close by the under-world where it was born. As it gets larger it ventures out and

takes its chances for life in the world of waters above it, usually, I think, going up some brook or keeping near some rocks, or close inshore where it can quickly retreat to a place of safety when alarmed. It feeds now voraciously on whatever it can find in the way of smaller fishes and insects and other animal life in the water, and in a few months, probably not over six or seven, it joins the host of its comrades, of about the same size, which are preparing to go to sea, and forming a school which, without doubt, gathers myriads of recruits as it proceeds, it hastens with all its might down the stream. It is now a beautiful silvery fish from four to six inches long, and in a few days finds itself in the midst of the allurements and dangers of the great unknown ocean which it was so eager to seek.

Strange as it may seem, very little, almost nothing in fact, is known of its ocean history. We know that the Salmon leave the mouths of the rivers at stated times and return to their rivers at other stated times, but where they go, or how they fare, or what motives guide their course in their mysterious ocean sojourns, no one knows. From analogies derived from our knowledge of the history of the Atlantic Salmon, we suppose that they go into deep water when they leave the rivers, and seek the best feeding places they can find, but that is about all one can say of their ocean history. The few facts that we know of this portion of their existence are pretty much confined to the following:

They are found to have deep-sea fish in their stomachs when they first make their appearance near enough to the mouths of the rivers to be captured, which points to the deep sea as their ocean feeding ground. They are also caught by the fishermen at Monterey Bay, which shows that they go as far south as Monterey, but does not show, what some claim, that the course of their migration is southward, for there may be hundreds of unknown places to the north where they could be caught if the fishermen were there. It only proves that some California Salmon go south to Monterey. One thing more is known about their ocean life, and that is that they are often caught with marks of seals' and sea-lions' teeth upon them, which shows that they are preyed upon in the sea by these enemies, though, perhaps, it is only in their journey to the rivers' mouths that they have to run the gauntlet of seals and sea-lions, for they probably have a capacity for standing deeper water than their just mentioned enemies.

THE RIVER ASCENT.—But if their ocean history is little known, their inland career, if I may use the expression, is interesting enough to make up for it. From the moment the Salmon enters the river, which it is sure to seek once in one or two years, its progress is one of interest. It first *proceeds, at its leisure, to the head of tide-water.* Here it stops awhile and seems to play about between the fresh and salt water. Whether it shrinks from encountering the sudden change from salt water to fresh, which is probably the cause of its dallying, or for other causes, it usually spends two weeks or more hovering about the border line between sea water and river water. When it has overcome its apparent repugnance to making the change to fresh water, it makes a rapid charge up the river for the clear gravelly streams which its instinct or sixth sense tells it to seek. Now, paradoxical or unreasonable as it may seem, it stops eating. If it is caught a short distance above the head of the tide, the undigested remains of what it ate in the salt sea water are sometimes found in its stomach, but after that nothing, absolutely nothing, is ever found inside of the California Salmon to show that it has eaten a particle of food in fresh water. As a proof of this statement I may mention that out of a great many thousand specimens that have been examined no food has been in the stomachs of any.

After the Salmon cross over the line into the fresh water above them they begin a strange and almost inexplicable journey. In the case at least of the Salmon that go up the McCloud River, they begin a journey which is a long fast, and ends only in death. If they could be credited with

a knowledge of what lies before them, none of the martyrs of Christendom could claim greater merit than these devoted Salmon that march on unflinchingly to inevitable death. From the time the Salmon leave the border land, so to speak, of tide water, they pursue their upward course towards the rivers' sources with an inflexible pertinacity. Nothing can now check their upward career, except an obstacle positively insurmountable, and nothing whatever can make them turn back. They steadily pursue their way through the deeper and stiller waters of the lower portions of the rivers. They dash furiously up the rapids, halting awhile usually before they enter them to recruit their strength, and continue to rush on and on through the swiftest, shallowest, and roughest waters until they reach suitable places for depositing their spawn. The earliest runs, that is, those that enter the rivers first, usually go farthest up the stream. Those that come in next seem to take their places below them, and so on down the river, so that there is a series of sets of spawning fishes, extending from the head of the river down as far as suitable spawning grounds are to be found; the set highest up the river spawning first, and so on down the river in regular order. If the Salmon on their way up a river meet with anything that frightens them, like a bridge for instance, they usually stop and cautiously examine it until they are satisfied that they can risk the venture, and then they all together, as if by a given signal, make a swift rush past it. When they come to a fall they show more perseverance than Robert Bruce's famous spider, for they try innumerable times to jump it, and never give it up until they have found it to be a hopeless case and are completely worn out with the exertion.

I said nothing can turn them back. When thoroughly frightened and panicked, however, they act like stampeded cattle and can be driven down the river in droves. The Indians take advantage of this weakness of the Salmon in one of their methods of capturing them. They build a trap nearly across a river that is not too deep for the purpose, and then great numbers of them wading into the stream a mile or two above the traps form a line across the river, and with sticks, poles, and branches of trees, use their utmost exertions to frighten the Salmon, till at last the fish, too astounded and panic-stricken to know what they are about, turn around, and heading down the river, rush with all their speed into the traps that are waiting for them.

In their course up the river it does not discourage them if the water is shallow. They will push on where the water does not cover their backs, and crowd together in doing so, till, as some one has jokingly remarked, they hardly leave room for the water.

There is something amazing about these pilgrimages of theirs up the rivers. The wonder is not so much that the Salmon go without food for so long a time—the black bass does the same—nor that they make such great exertions in getting up the rivers, for other creatures make greater exertions in getting their food, but the marvel is in the combination of these two facts, viz, in their making these exhausting efforts without taking any food to keep up their strength. It seems incredibly contradictory to nature's laws of life and offers a puzzling problem to biologists to discover where the fuel comes from which does this immense amount of work, accomplished by the migratory Salmon between leaving tide water and completing the season's spawning.

SPEED OF ASCENT.—Their rate of progress up the rivers varies between very wide limits. The earlier runs are the longest time on their way up the river. The latest runs make the journey most quickly. The fish seem to regulate their speed according to the forwardness of their eggs. When their eggs are very small or almost wholly undeveloped, as is the case with the earliest runs—that is, those that enter the mouth of the rivers first—they seem to be in no hurry, but loiter along as they please, and probably spend a great deal of time between the ocean and the fresh-water line; but when their eggs are nearly ripe, as is the case with the later runs, they

advance as if they had no time to lose, as indeed they have not, and hasten, apparently at the top of their speed, to their spawning destinations. This is illustrated by the fact that it is six or seven months before the early runs of the Sacramento Salmon, which enter the Golden Gate in November and December, reach the sources of the river at Mount Shasta, four hundred miles from the river's mouth, while the later runs, which reach Rio Vista about the 1st of August, arrive at the McCloud River, two hundred and fifty miles distant, in ten or twelve days.

When they have reached the vicinity of their spawning grounds they seem to rest two or three weeks in deep holes and eddies of the river, until they are just ready to build their nests, and then they emerge from their holes and literally cover the rapids for miles, in the clear shallow water of which they can be seen from the river banks by hundreds. They now, comparatively speaking, lose their fear of danger, and will not leave the places they have selected unless very closely approached, and then they will persistently return again and again unless actually driven off and kept off. Here comes in once more very noticeably the marvel of their living without food, for they now for many days stem the force of powerful currents every moment, day and night, not only without partaking of food, but in many instances without having taken any food for months. A copious rain starts a movement along the whole line from the river sources to tide water, except where the fish are actually engaged in spawning, and during the rain the river currents seem to be full of Salmon eagerly striving to reach higher portions of the stream.

SPAWNING HABITS.—After the Salmon have occupied the rapids a short time, they proceed to build their nests and deposit their eggs. They scoop away the gravel from a selected spot with their noses and sweep it off with their tails, until they have made clear a spot a few feet in diameter, usually about circular in shape, and depressed towards the center, not unlike in form a common hen's nest. The eggs and milt having been deposited, the nest is covered over again with gravel by the parent fish, which use their noses and tails as before to move the gravel. This being done, they seem, at least on the upper tributaries, to act as if they realized that their life-work was ended. They do not hasten back to the ocean, where, if they reached it, they would regain their pristine health and vigor, but they hover about the vicinity of their spawning ground, growing weaker, more emaciated and diseased every day, till death comes to their relief.

Having briefly traced the Salmon's career from the ocean to the final stages of its journey and its life, let us look for a moment at the various changes which gradually transform it from the healthy and magnificent creature of the ocean to the pitiable emaciated object calmly awaiting its final summons at the river's source.

When the Salmon come into the rivers from the ocean they are royal creatures wearing a beautiful silvery coat and possessing rare symmetry and immense vitality and muscular vigor. As long as they stay in tide water, there is saltness enough in it to keep up their appetites, and they are usually sufficiently successful in their foraging to hold their own. But the moment they cross the line into the fresh water of the rivers above them they lose their appetite, they take no more food, and from that day they fall off in symmetry, beauty, and vitality. This physical deterioration always bears a constant ratio to the proximity of their time of spawning, and regularly increases as this time approaches. As this spawning season occurs at different periods at different locations, no specific time can be named for their successive stages of deterioration, but taking the salmon-breeding station of the United States Fish Commission on the McCloud River as a point of observation, it is noticed here that the Salmon which pass the station in March and April are very much like the tide water fish. In May and June they are still in their prime. In July they change rapidly for the worse, and by the end of that month their silvery look is gone and they are of an olive-green color. The males are deeper and the females are broader. Their scales are nearly absorbed

into the skin, which has become smooth and slimy. The heads of the females have not changed much, but the heads of the males have become more or less pointed, their jaws have developed rows of large white teeth, and the whole expression of their face has become ferocious and repulsive in the extreme. They are now fast losing their marks of nobility with which nature had so richly endowed them in their broad ocean domains. They begin to spawn at the McCloud station the latter part of August, and from that time to the end, which soon comes, their downward progress is rapid. They grow less comely in appearance, more slimy to the touch, more unsymmetrical in form; parasites collect by thousands in their gills and under their fins; their tails and fins fray off; a white and loathsome fungus gathers over all parts of them, frequently destroying their eyesight; and swarms of suckers—the carrion-birds among fishes—wait about them to feed upon their lifeless bodies when they die. For some unknown and strange reason, the Salmon in the higher tributaries do not hasten back to the salt water which would clean their bodies of the parasites and fungus and restore their appetite and with it their health and vigor, but they linger, with a strange indifference to their fate, around the spots where they have deposited their eggs, waiting patiently for the only possible relief from their wretchedness, which is death.

Some uninformed persons, who have never seen these fish in their natural habits, have expressed some incredulity in regard to their all dying after they have spawned. Under this head, I will only say that it is probably true that those that spawn near the ocean return to the ocean and recover their vitality, but those that pass the United States station on the McCloud River in the summer never do. In order to make sure whether I was mistaken in my views about it, I took the testimony, a year ago, of all the white men who have lived or worked on the river, and of all the Indians I could reach. It was the unanimous testimony of all that the Salmon which pass the McCloud hatching station in the summer, on their way up the river to spawn, die in the river and never return to the ocean.

In conclusion I will say that the Quinnat Salmon has been a favored object of artificial culture. It was among the first of the fishes to receive attention from Professor Baird, the United States Commissioner of Fish and Fisheries, who, in 1872, deputized the writer to go to the Pacific coast to collect and distribute its eggs. Since that time over fifty million Quinnat Salmon eggs have been distributed over the world, or hatched for the benefit of the Sacramento River. Professor Baird has in some instances sent them as far as Denmark, Germany, Russia, New Zealand, and Australia.

163. THE NAMAYCUSH OR LAKE TROUT—SALVELINUS NAMAYCUSH.

The Lake Trout, or Salmon Trout, is a non-migratory species inhabiting the chain of Great Lakes from Superior to Ontario, as well as Lake Champlain and many other smaller lakes of the United States and of British America. With the exception of the doubtful species known as the "Siscowet," its nearest relative is the Brook Trout of the Eastern States, *Salvelinus fontinalis*. The Lake Trout is, in fact, a member of the same group of the salmon family with the Chars. Gill and Jordan were the first to point out that the true relations of the Lake Trout are with the Chars rather than with the Salmon. The Lake Trout is peculiar to North America and its inland seas, though the Char and the Black-spotted Trout are very similar to European forms. Every one is familiar with the phenomenon of the Land-locked Salmon, these fish being true Salmon for a time debarred from access to the sea, assuming a peculiar coloration, and with habits modified by confinement within narrower bounds than those of others of the same species which are free to range between river and ocean.

The Lake Trout appears to have undergone somewhat similar modifications. It is a Char, not land-locked, but placed under conditions directly opposite to those connected with those which

are land-locked. Certain modifications of structure have resulted from access to nutritious food in almost unlimited quantity and from existence for many generations in extensive bodies of water.

SIZE.—The most striking of these is the greater size. It sometimes attains the weight of one hundred and twenty pounds, while our common Char, *Salvelinus fontinalis*, even under similar conditions, never exceeds fourteen or fifteen. This is due, perhaps, to the greater ease with which, for hundreds of generations, the Lake Trout have obtained their food. They are almost always found in the same lakes with one or more kinds of white-fish, whose slow, helpless movements render them an easy prey, and upon whose tender, luscious flesh the Lake Trout feeds voraciously. From abundant food and slight exertion results bulk of body. This becomes hereditary. Even the eggs in time are larger, just as in the Land-locked Salmon they are smaller, than in the parent species, and the young fish begins its career with an advantage. As the nascent species gains in magnitude the scales, always small like those of the Char, increase in number, that the growing body may be covered. In like manner an additional ray or two may be developed to re-enforce the dozen supporters of the dorsal fin. The change in dentition is a result of the change of habits. Feeding upon large, strong-scaled fish, instead of insects and minnows, natural selection provides the Lake Trout with more and stronger teeth. It would perhaps seem like a hasty generalization to point to *Salvelinus fontinalis* as the form from which the Lake Trout has been developed, but one may fairly take into consideration the fact that this species alone, of all the *Salmo* group, is usually associated with the fish under consideration, occupying the streams which flow into the lakes of Northeastern America, and frequently entering these lakes. That *S. fontinalis*, even when retaining its predilection for the streamlets, shows a tendency to extraordinary growth when ample waters, like the lakes of Maine or the lower stretches of the Nepigon, are accessible, is also known.

VARIATIONS.—The Brook Trout shares with the Lake Trout its tendency to variations in size, shape, and color. Every lake of Northern New York and New England has its own variety, which the local angler stoutly maintains to be a different species from that found in the next township. Some are as black as a tautog, some brown with crimson spots, some gray, with delicate reticulations like those of a pickerel. The usual type to be found in the Great Lakes is brown or gray, dappled with lighter shades of the same general tint. Naturalists have been sadly misled by their Protean modifications. The "Namaycush" of the North, the "Togue" or "Tuladi" of the Maine and New Brunswick Indians and lumbermen, the "Siscowet" or "Siskawitz" of Lake Superior, the "Trout" of Winnipiseogee, and that of the Adirondack lakes, have each been honored with a distinct binomial.

The angling authorities still refuse to admit that the Lake Trout of the East is identical with the Mackinaw Trout, or Namaycush, supporting their views by accounts of their very different habits. A careful study of the dead fish is sufficient, however, to convince a trained observer that there are no structural characters by which these different forms may be separated into species. The local variations should undoubtedly be taken into consideration, and when these are better understood it is probable that zoologists and anglers will compromise by agreeing to consider the most strongly marked types as races, or breeds, such as are now recognized among dogs, pigeons, and other domesticated animals. Having never seen the fish called the "Siscowet," *Salvelinus siscowet*, I cannot express an opinion as to its distinctness from the Mackinaw Trout, but good ichthyologists assure me that its peculiarities are very slight, consisting chiefly in the smaller head-teeth, and fins, and the stouter body. Since, however, it is always distinguished from the Namaycush by the Indians and fishermen of Lake Superior, who often see them side by side, it seems probable that it may claim at least sub-specific rank. The matter of land-locking is one which

deserves more attention than it has hitherto received. From what we know of the influence of environment upon animals, it need not surprise us to discover that the fishes of each separate lake possess distinctive characters, rising, perhaps, to sub-specific value. No definite proof can be gathered, however, until large series of specimens from each body of water have been examined and compared.

LAKE TROUT IN THE GREAT LAKES.—The Lake Trout reaches its greatest perfection in the northern parts of lakes Huron, Michigan, and Superior, where it is quite generally known as the "Mackinaw Trout." In the lakes of Northern New York the same species occurs, being known by the names "Lake Salmon," "Lake Trout," and "Salmon Trout." This form, which is considerably smaller than that of the northern lakes, was described by DeKay under the name *Salmo confinis*, and was observed by this author as far south as Silver Lake, in Northern Pennsylvania. Still another form is recognized by sportsmen, which, although undoubtedly specifically identical with that of the Great Lakes, has been described under various names, such as *Salmo toma* and *Salmo symmetrica*.

"This fish," writes Lanman,[1] "is found in all the great lakes of New Brunswick, and in very many of those of Maine, but it is believed not to exist in the lakes of Nova Scotia. It is called by the lumbermen the 'Togue'; the Indians designate it by a name equivalent to 'Fresh-water Cod.' It is found in great numbers and of large size in the Eagle Lakes, at the head of Fish River, in the Saint Francis lakes, from which it follows the river of that name, and in the Matapediac Lake, which discharges itself into the Restigouche, and in the Miramichi Lake, at the head of that river. In Lake Temiscouata this fish has been taken of the weight of twenty-one pounds. It is there called the '*Tuladi*.' It is often taken of the weight of twelve pounds and upwards in the Cheputnecticook lakes, at the head of the eastern branch of the Saint Croix. It has been found of late years that this species of fish exists in considerable numbers in Loch Lomond, twelve miles from the city of Saint John."

Hamlin writes:[2] "This Trout inhabits many of the great lakes and deep mountain torrents of Maine and New Brunswick, but it is believed not to exist in those of Eastern New Brunswick, which singular hiatus in its distribution, perhaps, may be explained by the absence of deep waters in that country. It haunts the deepest waters, where the cold or the repose to which it leads favors that development and conservation of fat which is indeed a characteristic, and it steals forth in quiet at the approach of twilight or at early morn to the shoals and the shores in quest of its prey."

The Winnipiseogee Trout,[3] somewhat abundant in Lake Winnipiseogee and supposed to occur in Lake George, is also a form of this species, closely related to the Togue.

The popular and scientific names which have been given to this species are due to the wonderful tendency of variation in size, shape, and coloration which this species, like the Brook Trout, exhibits. Every lake in which they occur has its own varieties, which local authorities believe to be quite peculiar. Some are black, some brown, with crimson spots, some gray, with delicate reticulations like those of a pickerel. The usual type to be found in the Great Lakes is brown or gray dappled with lighter shades of the same general tint. Throughout Lakes Superior, Michigan, and Huron the fishermen are generally of the opinion that there are at least two kinds of Lake Trout. It seems probable, however, that they are led by superficial characters, finding it con-

[1] Report United States Fish Commission, part 2, p. 220.

[2] *Ibid.*, p. 356.

[3] *Salmo symmetrica*. PRESCOTT: Silliman's Journal, 2d series, ii, p. 340. Report United States Fish Commission, Pt. 2, p. 257.

venient to give names to the extremes of development in different directions, and neglect to take into account the forms intermediate between these extremes. Mr. Kumlien studied the subject in different localities in the summer of 1880, and the results of his observations are here presented.

In the vicinity of Green Bay those having salmon-colored flesh were called "Black Trout," while others, with white flesh, were known as "Lake Trout." On the eastern shore of Green Bay, on the east shore of Lake Michigan, two species of "Mackinaw Trout" are recognized by the fishermen. About Grand Traverse Bay, Lake Michigan, two varieties are also recognized, one being long, slim, and coarse-meated, taken in shallow water, and are known as "Reef Trout," or when very large are called "Racers"; they are supposed to follow the schools of white-fish, among which they are always taken; those of the other form are called "Pot-bellies," being short and chubby, and invariably taken in deep water. In the vicinity of Two Rivers, Wisconsin, two forms are recognized, one known as "Reef Trout," corresponding to the one just mentioned, large and lank, with tough and coarse flesh, while the other, which is much more highly prized, is taken in deep water. At the south end of Lake Michigan two forms are known: one, which is darker-colored and has red flesh, being considered by far the more valuable. At Grand Haven there are two forms of Mackinaw Trout, known as the "Shoal-water Trout" and the "Deep-water Trout." In the vicinity of Thunder Bay, Lake Huron, the name "Buckskin" is applied to one variety, which is held in very slight esteem, while another form is known by the name of "Racer."

The angling authorities as well as the fishermen refuse to be convinced that ichthyologists are right in including all the Lake Trouts in one species; the former are especially dissatisfied that the Lake Trout of the East should be thought identical with the Mackinaw Trout of the Northwestern and Great Lakes, and they support their views by reference to their very different habits. Local variations should, undoubtedly, be taken into consideration, and when these are better understood it is probable that zoologists and anglers will compromise by agreeing to consider the most strongly marked types as races or breeds, such as are now recognized among dogs, pigeons, and other domesticated animals.

NAMES.—In addition to the names which have already been mentioned, the Lake Trout has other appellatives, such as "Lunge," in Canada; "Tyrant of the Lake," "Laker," "Red Trout," "Gray Trout," "Black Lunge," "Silver Lunge," "Racer Lunge," "Black Salmon," and "Lake Salmon." The name "Tuladi" is said to be derived from Lake Toledi at the head of the Saint John River, of New Brunswick.

IMPORTANCE.—"The Trout of the Great Lakes," writes Milner, "is one of the three most numerous fishes, and, except the sturgeon, attains the greatest weight of any of the Lake species. It is captured almost exclusively in gill-nets, and in some portions of the Lakes they take them in pound-nets during the spawning season. In winter a great many are taken in the bays through holes cut in the ice."

SPAWNING.—In the spawning season they approach the shore, but do not ascend the rivers, and although they are known to exist in a few inland lakes, connected with the main lakes by rapids, there is no record of their having been seen or taken in the outlets.

The observations of Mr. Kumlien concerning the relative abundance of this species in different parts of the Great Lake region, and the periodicity of their movements, are deemed of sufficient importance to be recounted somewhat at length below. The whole subject of their movements is, however, so closely connected with their habits during the spawning season that it is perhaps desirable to discuss first their breeding habits. The spawning season in Lakes Michigan and Superior occurs in October. Their habits at this time have not been studied by any zoologists, the visits of Milner and Kumlien to their haunts having been made at other seasons of the year.

They spawn late in October, coming up to the rocky shoals and reefs in from seventy to ninety feet depth of water. They are said to spawn close to the projections and edges of cavernous rocks, the eggs settling into the depressions, where they doubtless remain until hatched. The young fish make their entry into the world in late winter or early spring, though in a hatching house, with water at an average temperature of 47° Fahrenheit, they have been known to hatch the last week in January.

Milner remarks: "The universal testimony is that the spawn is found running from the females in the latter part of the month of October, the fish coming to the spawning grounds a week or more earlier. At Detour, at the head of Lake Huron, on the 16th of October, I saw a large lift of Trout brought in from the spawning grounds; the ova were large and separated, but were still entirely retained in the folds of the ovaries, and the fishermen said that they had not found them running from this fish as yet.

"The localities selected by the Trout for their spawning ground are usually rock bottoms in from fifteen fathoms to seven feet of depth. The Trout are said to settle close to the projections and edges of the honey-combed cavities of the rock, and that frequently, when a loose fragment of the rock is drawn up by the nets, the cells are found to contain numbers of the eggs."

Mr. Milner counted the eggs of a Mackinaw Trout, of twenty-four pounds' weight, and found that there were 14,943. The average weight of these fish as taken in the gill-nets was about five pounds, though fish of fifteen pounds are frequently seen. Mr. Milner obtained authentic accounts of one, taken at Mackinaw in 1870, which weighed eighty pounds. The species is the largest, except the sturgeon, occurring in the Great Lakes.

"The knowledge of the time at which the young fish make their appearance is limited to the experience of the few fish-culturists in the country who have hatched the eggs. In water of an average temperature of 47°, they are found to hatch about the last week of January. At the lower temperatures of the water, in a state of nature, their development would be retarded for several weeks.

"Of the habits of the young Trout I am entirely destitute of information. I have seen one of eight inches in length, and learn of rare instances in which the fishermen have seen small ones."

The principal spawning grounds of the Lake Trout are the following:

I. The north shore of Lake Superior, from Duluth northward to the vicinity of Isle Royale, comprising the whole lake coast of Minnesota, and in all the small bays of the region.

II. In the vicinity of the Apostle Islands, in the western part of Lake Superior, especially about Gull Island.

III. Very extensive spawning grounds in the vicinity of Huron Bay, Michigan, particularly near L'Anse and Bête-Grise Bay, and on a reef about four miles from Porte Gentre.

IV. Very extensive spawning grounds in the southeastern part of Lake Superior, at Big Presque Isle, Laughing Fish Island, Sharp Point, and Sauk's Head, Michigan.

V. On the west shore of Lake Michigan, from Racine northward, particularly upon a reef about forty miles off Milwaukee, and on a smaller reef about six miles from the same town. On this ground, according to Milner, a large type of Trout has been taken for many years, also on certain shoals in the vicinity of Green Island in Green Bay.

VI. On the eastern shore of Lake Michigan, from Saint Josephs northward.

VII. In the vicinity of Detour, at the head of Lake Huron. At this point, according to Milner (also according to Kumlien, along the islands off Thunder Bay and Harrisville), the spawning ground was so close to the shore that the tips of the floats of the nets set upon it were visible above water.

VIII. On the Canadian shore of Lake Ontario.

"Their usual home at other seasons than the spawning period," remarks Milner, "is in deep water. A few stragglers approach the shore and are taken in the pound-nets or with the hook from the piers extending into the lakes. In the northern portions of Michigan they are taken in fifteen fathoms in some numbers with the gill-nets, and more plentifully through holes cut in the ice in the winter time, though a depth of over thirty fathoms is more favorable for their capture."

Milner made the following remark: "Pound-nets have not made extensive inroads upon their numbers, and none but mature fishes are taken."

In Green Bay alone does it appear that small-meshed gill-nets have interfered with the abundance of the fish by capturing their young.

The best study of the habits of this species, as an inhabitant of the Great Lakes, was that made by Milner, in 1871. He observed that in Lake Michigan, except in the spawning season, they remain in the deepest parts of the lake. In their autumnal migrations they do not ascend the rivers, and although they are known to exist in a few small inland lakes, connected with the main lakes by rapids, there is no knowledge that they have ever been seen or taken in the outlets. In the northern parts of Lake Michigan they are caught in depths of fifteen fathoms in small numbers by the gill-nets, and more plentifully through the ice in winter, chiefly at a depth of more than thirty fathoms.

Food.—They are ravenous feeders. In Lake Michigan, where a careful investigation into the nature of their food was made, it was found that they were preying upon the cisco (*Coregonus Hoyi*), a well-known fish closely resembling the white-fish. Mr. Milner was inclined to combat the generally accepted theory of the fishermen that they are large consumers of young white-fish, stating that for a great part of the year they live in much deeper water than is resorted to by the *young white-fish, though Trout straying into shoal water, or migrating upon shallow spawning* grounds, would undoubtedly prey upon the smaller white-fish as readily as they would upon any other species.

It is not uncommon for a Trout to swallow a fish nearly as large as itself. One measuring twenty-three inches was brought ashore at Two Rivers, Wisconsin, from the mouth of which some three inches of the tail of a fish (*Lota maculosa*) projected. The "lawyer," when taken from the Trout, measured about seventeen inches. "Their exceeding voracity," writes Mr. Milner, "induces them to fill their maws with singular articles of food. Where the steamers or vessels pass, the refuse of the table is eagerly seized upon, and I have taken from the stomach a raw peeled potato and a piece of sliced liver, and it is not unusual to find pieces of corn-cobs, in the green-corn season."

Kumlien's observations led him to believe that large Trout feed, to some extent, upon white-fish, while the smaller ones capture the herring. In Green Bay the fishermen say that the Trout leave the white-fish spawning beds in autumn before the spawning season begins, but that they are not accused of being troublesome spawn-eaters, though otherwise extremely voracious, and especially hurtful to the white-fish and herring. The fishermen of Port Huron informed him that it was no unusual occurrence to obtain white-fish two or three pounds in weight from the stomachs of large Trout. Captain Dingman, of Beaver Island, informed him that the Trout do not come upon the white-fish reefs during the spawning season, and that they do not trouble the white-fish at that time. In that vicinity they are thought to prefer herring to any other kind of fish. A twenty-pound Trout was caught off Beaver Islands which had in its stomach thirteen herrings and was caught biting at the fourteenth. They are as omnivorous as codfish, and among the articles which

have been found in their stomachs may be mentioned an open jack-knife, seven inches long, which had been lost by a fisherman a year before at a locality thirty miles distant, tin cans, rags, raw potatoes, chicken and ham bones, salt pork, corn-cobs, spoons, silver dollars, a watch and chain, and, in one instance, a piece of tarred rope two feet long. In the spring wild pigeons are often found in their stomachs. It is thought that these birds frequently become bewildered in their flight over the lakes, settle on the water, and become the prey of the Trout.

In the review of localities already given mention has been made of many large individuals; the only estimate of average accessible is that by Milner, who remarks: "The smallest ones that are taken in any numbers are fifteen to eighteen inches in length, and these are not very numerous. The average weight of the Lake Trout taken in the gill-nets is nearly five pounds. It is claimed that in years past they averaged much higher. They are quite frequently taken weighing fifteen pounds. A specimen of a female was obtained last summer at Shoal Island, Lake Superior, weighing twenty-four pounds. One taken at Grand Haven, Michigan, in the month of June, 1871—a female—weighed thirty-six pounds and one-half. After the gills and entrails were removed it weighed twenty-nine pounds. It measured three feet six and one-half inches in length.

"The tradition of the largest Trout taken is preserved at each locality, ranging from fifty to ninety pounds. One that I am satisfied was authentic, from having taken the testimony of those who saw it weighed, and having the story confirmed by Father Peret, of Mackinaw, was taken at that place in 1870, and weighed eighty pounds."[1]

ENEMIES.—"There are no species of fishes in the lakes," writes Milner, "sufficiently formidable to be considered enemies of the Trout after they mature. The spawn and fry probably suffer to some extent from the same causes that the ova and young white-fish do. They are troubled with a few parasites, especially a tape-worm that is found very numerous in the intestines of some of them. Solitary individuals, known among the fishermen as 'Racers,' are found in the summer time swimming sluggishly at the surface. They are easily taken with the gaff-hook, and bite readily at any bait thrown to them. They are always very thin in flesh. Dissection of the few that I have taken failed to find any adequate cause for their condition. The parasites were generally present, but not in any larger number than in healthy fish. The fishermen on the north shore of Lake Michigan generally keep a few hogs. The offal of the white fish is fed to them freely, but they are very careful to allow no trout offal to be thrown in their way, asserting that the hogs, after eating Trout, frequently become crazy and die. The only plausible explanation of this fact, if it is a fact, is that some entozoon of the Mackinaw Trout passes through one stage of its development in the hog, and occasions disturbance of the brain, having much the same habit as the cystic *Cœnurus* does in the sheep. Dr. Bannister informs me that the opinion prevailed among some of the Russian residents of Alaska that a tape-worm was occasionally produced in the human subject by eating the *Chaiwicha*, *Salmo orientalis* Pal., the largest species of Salmon common in that country. The fact that it was quite a common practice to eat fish frozen, or dried, or salted, without cooking, would favor the introduction of any parasite existing in the body of the fish."

The livers of Lake Trout are thought by the fishermen to be poisonous. Mr. James Patterson, of Manitowoc, Wisconsin, cites an instance, which occurred not many years ago, where all the members of a family were poisoned by eating trout livers, and were a long time in recovering from the effects.

CULTURE.—"The Lake Trout has for years been the subject of attention on the part of the New York State commissioners, and their agent, Seth Green, who every autumn collects millions

[1] MILNER: Fisheries of the Great Lakes.

of eggs from the fisheries on the Canadian side of Lake Ontario to be hatched at Caledonia, New York, for distribution to the lakes in the interior of New York. The experiment has lately been made of planting the young fish in running water, as the Susquehanna, etc.; but it yet remains to be seen how they will thrive. The Lake Trout is eminently worthy the attention of States along the Great Lakes, since, with the white-fish, it constitutes by far the most important element in the great fisheries."[1]

In the fall of 1857 and 1858 a large number of eggs of Salmon Trout were obtained for Saltonstall Lake, in Connecticut, from Lake Ontario. A considerable number of this species, obtained in Lake Ontario, was introduced into Newfound Lake, New Hampshire, in 1871, by the State commissioner. The enterprise is referred to more fully in the report of the United States Fish Commission.[2]

A minor experiment in hatching Salmon Trout, or Mackinaw Trout (*Salmo namaycush*), was made by Mr. Samuel Wilmot, of Newcastle, Canada, in 1868. He also obtained a hybrid between a male *Salmo salar* and a female *S. namaycush*. The next published records we have of experiments are by Seth Green and by N. W. Clark in 1870. Mr. Clark's was with but a few eggs. In an address before the legislature of Michigan he refers to the fact of having young Salmon Trout on exhibition. The quantity of eggs taken by Seth Green that year and hatched was very large, and the fish proving to be a great favorite among the people of the State he has continued to breed it on a large scale, and it has been widely distributed throughout the State. The greatest drawback in the culture of this species is the difficulty and danger attending the procuring of the eggs. The spawning places of the fish in the region of the hatching-houses are in the open lake, and the time when the ova are ripe is in October, when there are frequent storms, so that going out in an open boat to the nets is a task of hardship and danger, and has resulted, in a late instance, in the loss of six men, one of them Marcellus Holton, an accomplished fish-culturist and the inventor of the Holton hatching-box. There are, however, points on the lakes accessible by steamer, though not contiguous to the breeding establishments, where the salmon-trout spawning grounds are near the shore, and even entirely land-locked from wind and sea.[2]

Neither the Mackinaw Trout nor the Siscowet are game fishes in high esteem, though the latter is taken by trolling with a bright-colored fly, with a minnow bait, or a spoon-hook. It does not rise like the Brook Trout, and its play is likely to be sluggish and sulky. It is also taken with a bottom line on grounds which have been previously baited. The Indians of the Sault Ste. Marie display great skill in spearing the Mackinaw Trout through the ice, luring them within reach by means of decoy fishes of wood or lead. By far the largest quantities are taken in pounds and gill-nets in the Great Lakes.

In Lake Superior Lake Trout are caught principally in September, October, and November in pounds and gill-nets. Formerly they were fished for with hooks only, but of late years this practice has been abandoned by professional fishermen. In the Green Bay region large Trout are caught principally with hooks, though in the western part of the bay and in Oconto Bay many are taken in gill and pound nets in deep water. Those captured in the gill-nets are thought by the fishermen to be meshed, for the most part, while these nets are being lifted; the Trout dart after the other fish which have been gilled and thus become entangled. In Lake Huron they are caught entirely with gill-nets. They may be taken with hooks baited in the ordinary way, but can hardly be said to afford sport to the angler, since they allow themselves to be pulled to the surface as easily as codfish do.

[1] Professor BAIRD: Report, United States Fish Commission, part ii, p. lxxii.
[2] Report, U. S. Fish Commission, part ii, p. 534.

The Togue or Lunge of our northeastern boundary is held in much higher favor by the angler. Hallock states that the young fish rise freely to trout-flies in rapid water, while the adults are extremely voracious, particularly in May and June, when they can be taken near the surface.

Prof. Arthur L. Adams, in "Field and Forest Rambles," gives a vivid picture of the habits of this peculiar type: "It repairs to shallows to feed on Trouts, smelts, and the like; indeed, the last-named fish would appear to constitute its favorite winter subsistence. It preys extensively, also, on eels and cyprinids, and is in fact a tyrant with an appetite so voracious that quantities of twigs, leaves, and fragments of wood are constantly found in its stomach. The great monster will sometimes rise to spinning tackle, but in so sluggish and undemonstrative a manner that the troller may fancy he has caught a water-logged pine or stone. In this way I had my line checked in Schoodic Lake, when, striking gently, I found I had missed a large Togue, whose trenchant teeth had made a series of deep furrows in the chub with which the hook was baited. It is naturally sluggish and inert, and apparently much of a bottom feeder. As we glided along the shore of one of the islets, composed more or less of granitic bowlders, our attention was directed by the guide to a large black object on the bottom, among a mass of stones. This he asserted was a monster Togue, which, if such was the case, must have exceeded three feet in length; moreover, he showed us two notches on the side of his canoe, representing the dimensions of an enormous individual which an Indian had speared in the same waters during the spawning season, the admeasurement being no less than four feet five inches."

TROUT IN THE GREAT LAKES.—The following facts concerning the abundance of the Lake Trout in different parts of the Great Lakes were gathered by *Mr. Kumlien in 1880:*

"In the western part of Lake Superior, according to common testimony, the Lake Trout is second in importance to the white-fish; they constitute about one-half of the catch of the gill-nets.

"In the vicinity of Whitefish Point the Lake Trout is more abundant than any other species. The average size is from ten to sixteen pounds. About the Apostle Islands they are abundant at all times and in all places; one was caught at Oak Island weighing fifty-seven and one-half pounds when dressed. In the fall the best fishing grounds are off Isle Royale, and nearly all the gill-nets are fishing there; it is not unusual for a single net to take one or two barrels at a setting. In Huron Bay and vicinity Lake Trout are abundant everywhere, except in the most shallow bays, especially about Stanard's Rock. On this reef, in 1880, one Mr. Egerton caught with one hook enough Trout to weigh, after dressing, six hundred pounds. In the winter of 1878 one specimen was caught through the ice, in a gill-net, at Porte Gentre, that weighed seventy-four pounds. Thirty-five and forty pound fish are common on the off-shore shoals. On the southern shore of Lake Superior, from Grand Island to Sauk's Head, this species is more abundant than any other. They are caught principally in September, October, and November. In the vicinity of Grand Island, in the opinion of Mr. Parker, a local authority, there has been no marked decrease in numbers during the past fifteen years. Individuals weighing from forty to fifty pounds are by no means unusual, and much larger ones are reported.

"In Green Bay, Lake Trout are reported to be far less common than formerly. In the southern part of this bay, in the vicinity of Bay City, they are now rare; somewhat more abundant from Oconto to Peshtigo, though not taken to any considerable extent, and north of Menomonee they are less plentiful than about Oconto. Seven to ten years ago, at Washington Island, it was not an unusual thing for men trolling for Trout to fill their boat in a short time, but this cannot now be done. The decrease is accounted for, by local observers, by the injudicious use of small-meshed pound-nets, which are supposed to capture great quantities of young Trout.

The largest individuals on record from this locality relate to one specimen, caught in 1864 at Grand Haven, which weighed eighty-eight pounds, and one taken at Oconto in 1876 weighing forty-five pounds. At the north end of Green Bay they are reported as very abundant at all seasons, though less common than the white-fish. They are most common about Saint Martin's and Gull Islands. In the fall and spring they are less abundant towards the heads of the bays. About Milwaukee they are abundant, particularly at the spawning season, though not so plentiful as formerly. A little farther north, in the vicinity of Manitowoc, they are plentiful. In 1855 Mr. Patterson caught one that weighed fifty-seven and a half pounds, dressed. Capt. J. Gagnon says that he has often taken a dozen at a single lift which would average twenty-five to thirty pounds in weight; these were taken in ninety fathoms of water, about fifteen miles from shore, off Two Rivers. The "Salmon-fleshed" and "White-fleshed" Trout are both found, but the former is far the more abundant and sells much more readily. At Racine they are very abundant and of considerable importance. During spawning time they are taken plentifully on a reef a short distance north of the city, but it is thought that they are decreasing in numbers. At Waukegan they are abundant in June and July and in the fall months, but, since the pound-nets are taken up in September, few are caught late in the fall. The fishermen claim to be able to tell from which locality any fish has been obtained, those from the clay bottom being short, thick, and fat, resembling the Siscowet. Individuals have here been caught which weighed sixty-five pounds. The common weight for a "Racer" is twenty-five pounds, and from this up to forty pounds.

"In the vicinity of Chicago, according to Nelson, Lake Trout are common in spring and fall. They commence running in the middle of April, and are taken at that time with set lines at a short distance out from the shore. "They are taken most plentifully in spring," continues Kumlien, "when the fishing first begins and before the runs of white-fish come on; at this time they are caught in from twelve to sixteen fathoms. Later they retreat into the lake, where, at a distance out from seven to nine miles from shore, they are found at all seasons."

"At New Buffalo and vicinity the Trout make up about one-fourth of the entire amount of fish taken. Fourteen years ago fish of from fourteen to twenty pounds' weight were obtained at every lift of the nets, but now they are much smaller. The largest ever known here weighed sixty-two pounds dressed.

"On the eastern shore of Lake Michigan, the Lake Trout is next in importance to the white-fish. At Ludington, Manistee County, they are very abundant. The runs begin early in May, but they decrease in number until July, after which none are taken until October. Gill-net fishermen obtain them throughout the winter in deep water. At Grand Haven they are said to be equally common all the year round, possibly because there are no spawning grounds in the vicinity.

"In the vicinity of the Straits of Mackinaw, in the northern part of Lakes Huron and Michigan, Mackinaw Trout is considered, next to the white-fish, the most important species. There is, however, a general opinion among the fishermen that they are much too numerous, for they are thought to be very destructive to young white-fish. As many as nine thousand pounds have been packed for shipment at Mackinaw in one day. They were formerly bought by the "count," as they ran, at three cents apiece. On Spectacle Reef, according to Captain Ketchum, two men lifting their nets every two hours, have caught thirty-six hundred pounds in one night. In the vicinity of Spectacle Reef Captain Coats reports them as even more abundant than the white-fish, though he thinks that at least eight times as many white-fish as Trout are shipped from Mackinaw. It is believed by the fishermen of Grand Traverse Bay that, when the moon is full, the Trout are much more abundant than white-fish.

"On the Michigan shore of Lake Huron, about Thunder Bay, Lake Trout are very abundant in August, and especially about Thunder Bay Island, where the men employed at the life-saving station gained quite a revenue by fishing for them. The best and most productive grounds in this vicinity are near Harrisonville and southward along the coast for a few miles. There are some fishing grounds north of North Point where all the Trout are said to be very large. In the vicinity of Saginaw Bay they are abundant, but will not rank commercially higher than fourth or fifth. Not many are taken in the pounds in Saginaw Bay, but the deep-water pounds, especially those about the Charity Islands, obtain a few. In April few fish other than Trout are taken in the gill-nets. In the vicinity of Port Huron they are very abundant, and it is the prevailing opinion among the fishermen that they are increasing in numbers, more being taken now than ever before. Very few enter the Detroit River. In the western part of Lake Erie, about Toledo, they are exceedingly rare, and unknown to many of the fishermen at Port Clinton. No instance of their capture is on record, and at Locust Point they occur only very rarely. About the islands off Sandusky they have in two or three instances been captured, and at the other fisheries in this vicinity local authorities do not think that more than five or six are taken in the course of a year. About Huron and Vermillion, Ohio, they are also very rare. It sometimes happens that one or two are taken in the course of a year's fishing; those which are here taken are always small, scrawny, and sickly. The same statements are made concerning Black River and Cleveland. Some are taken at Cleveland, but never more than three or four in a year. About fourteen years ago four were taken in Brownhelm Bay, but none since. They have never been taken at Black River; a man who has fished there for twenty-five years has never seen one. In the vicinity of Conneaut, Ohio, a few are occasionally taken in the spring. At Painesville, Ohio, they are rare. In 1869 only a single specimen was taken, and in 1878 only six. The wandering gill-netters who fish off Painesville sometimes capture a few in deep water. The only locality in Lake Erie where they are at all abundant is at Barcelona, New York, where there is said to be an extensive spawning ground five or six miles long, and about three miles from the shore. Some years ago the fishermen used to load their boats with Trout, sometimes as many as eighteen hundred pounds of dressed fish being taken with a small gang of nets. At Conneaut a few are taken in the spring. In the eastern end of Lake Erie they are caught to some extent, especially in the very deep water off Erie Bay, though they are not very plentiful. Off Dunkirk they are much more common, and in 1866 a specimen four and one-half feet in length, weighing seventy pounds, was captured. The fish dealers of Erie, Pennsylvania, claim that the Trout here taken are very different from those of Lake Superior; as a rule, only those with white meat are found.

"In Lake Ontario, especially in its eastern portion, about Cape Vincent, they are very abundant, and in the headwaters of the Saint Lawrence, as far down as Alexandria Bay; they enter the river only in winter and for the purpose of feeding. In abundance they rank far below the white-fish, three times as many white-fish as Trout being usually taken. In Chaumont Bay they are becoming less common, and at the present time are not very abundant, ranking sixth in importance, while at Cape Vincent they are third. The Trout handled at Chaumont are almost entirely from Canada, and the dealers do not depend upon the supply from American waters. At Oswego they are caught in the lake, though not entering the Oswego River. They are not plentiful at Port Ontario, although they have been in some seasons past. Since alewives came few Trout have been caught. The alewives are now so abundant that the Trout do not come near the shore to seek for food. In 1860 thirteen hundred pounds were caught in one night on five hundred hooks."

THE SISCOWET—SALVELINUS NAMAYCUSH VAR. SISCOWET.

The Siscowet, or "Siskawitz," is a form of Lake Trout which, according to many authorities, is a distinct species, and which has been observed only in Lake Superior. Having never seen the fish in a fresh condition, I cannot express an opinion as to its distinctness from the Lake Trout, but good ichthyologists assure me that its peculiarities are very slight, consisting chiefly in the smaller size of the head, teeth, and fins, and in its having a stouter body. Since, however, it is always distinguished from the Lake Trout by the Indians and fishermen of Lake Superior, who often see them side by side, it seems possible that it may claim a sub-specific rank. It was first described in 1850, in Agassiz's "Lake Superior,"[1] under the name *Salmo siscowet*. Herbert, in his "Fish and Fishing," p. 17, gives the following description of its peculiarities:

"This fish, like the former species, came frequently under my eye during my late northern tour; and I rejoice in the possession of a barrel of him in his pickled state, which I procured at the Sault Ste. Marie, on the strength of which I can recommend him to all lovers of good eating as the very best salt fish that exists in the world. He is so fat and rich that when eaten fresh he is unsufferably rank and oily, but when salted and broiled, after being steeped for forty-eight hours in cold water, he is not surpassed or equaled by any fish with which I am acquainted. Since my return he has been tasted by very many gentlemen of my acquaintance, and by no one of them has he been pronounced anything less than superlative. His habits closely resemble those of the 'Namaycush,' and, like him, I cannot learn that he ever takes the fly or is ever taken by trolling. I do not, however, believe that either of these methods is often resorted to for his capture, although there are many scientific fly-fishers about the Sault, and the Brook Trout of those waters are principally taken with large and gaudy lake-flies. The average weight of the 'Siskawitz' does not exceed four or five pounds, though he is taken up to seventeen. His excellence is so perfectly understood and acknowledged in the lake country that he fetches double the price per barrel of his coarser big brother, the 'Namaycush'; and he is so greedily sought for there that it is difficult to procure him, even at Detroit, and impossible almost at Buffalo."

Milner states that the Siscowet lives at depths greater than forty fathoms, and feeds chiefly upon a species of fresh-water sculpin. It spawns in September in deep water. The average size is about four and one-half pounds. Two five-pound fish yielded respectively 2,796 and 3,120 eggs. This species, like the Lake Trout, is for the most part taken in gill-nets.

Mr. George Barnston, of Montreal, Canada, formerly of the Hudson Bay Company, who made an extensive natural-history collection on Lake Superior, claims that there is a third species of Lake Trout, different from the Siscowet, on the south shore of Lake Superior, called the "Mucqua" or "Bear Trout."

Mr. Robert Ormsby Sweeny, chairman of the Minnesota fish commission, in a letter dated Saint Paul, Minnesota, October 19, 1880, conveys the following information concerning the Siscowet, which is more precise and comprehensive than anything hitherto published:

"I have not only examined the Siskowet carefully myself and compared them with Agassiz's formulas, but asked and consulted with traders, voyagers, Indians and half-bloods, and fishermen, in regard to their habits, size, color, weight, etc., and all come to the same conclusion. They are not possibly a 'Namaycush' and should never be considered the same fish. The name 'Sis-ko-wet' is an Ojibewa word, and means literally 'cooks itself.' It is so fat that you can set fire to it and cook it by itself. The fish when fresh is most deliciously rich, tasting like the belly of a mackerel, and with salt and potatoes to the hungry fisherman or hunter is a complete *menu*. The 'Namay-

[1] P. 333, plate 1, fig. 3.

cush' is dry and lacks delicacy, and cannot be even fried without pork-fat or lard. Some years ago I spent a winter at the head of Lake Superior, and our diet most of the time was fish and potatoes; only twice during the winter did we have fresh beef. At almost every meal and every day we had fish in some of its numberless styles of preparation, and you may be sure I became quite familiar not only with the taste, but the appearance of both Namaycush and Siscowet. As an edible [fish] the two are no nearer alike than fresh mackerel and sucker, but, of course, that would not be conclusive if there were no other differences.

"The amateur is likely to confound the Namaycush with the Siscowet, but when the differences are once pointed out, no confusion of the two again arises. The fishermen recognize them before taken from the water when hauling in the nets; even the Indian children know them at a glance. The head of the Siscowet is shorter and broader in proportion, eyes nearer the end of nose and are wider apart; the whole osseous structure of the head lighter, more delicate and flexible, particularly the sub-maxillaries, which in the Namaycush are heavy, rigid, and rounded. I intended to send you some Namaycush heads for comparison, but all of those procurable have had tongues and gills removed, so that the heads are in consequence unnaturally compressed and their characteristic appearance altered. The only variation from Agassiz's description that I find is in the lingual teeth; sometimes there is a furrow or a groove in the tongue, and between the 'pair of lateral rows' a V-shaped row is found, but this is so inconstant in occurrence as to be the exception. The coloring varies in different specimens considerably, according to locality from whence taken. The spots or markings are unlike those of the Namaycush, more even in size and shape, and more decided and stronger in color, and I can clearly see in some specimens that the spots are compound or an indistinct quincunx arrangement. The Namaycush spawn only in the fall, beginning in October. We have just taken half a million eggs. The Siscowet, I am told by the fishermen and Indians, are always spawning, or that ripe females are taken at all times of the year. At first I thought this an exaggeration, but I find it so very universally reported and by reliable men that I give it credence. They are very rarely found at the lower parts of the lake. They begin to be more plentiful as La Pointe is reached and most plentiful along the north shores and Isle Royale, but still they are a rare fish, comparatively. If one barrel of Siscowet to fifteen Namaycush are caught, they are said to be *very* abundant. They are so much prized that they bring a higher price, and it is rare that we get them here unless in winter time, when they are frozen and brought down fresh. A peculiarity I have noticed is, in winter when pulled out on the ice they puff up like a pouter pigeon full of air around the pectoral region, and when frozen can be instantly distinguished at a glance. They rarely exceed thirty pounds in weight and thirty-six inches in length, I am told by those very familiar with the fishes of the lake. On the same authority I learn that Namaycush reach ninety pounds' weight and six feet in length sometimes. I have just had a talk with a man from the lake, and he says this season they are catching about five Siscowet to the one hundred Namaycush only. Another fact: Siscowet are never caught alone, but always among Namaycush; but sometimes no Siscowet are seen or caught for weeks, and then they appear and disappear without disturbing the movements of Namaycush. You will find it impossible to keep Siscowet in alcohol, but I think the camphor water and glycerine will do it. I have succeeded with salmon thus, although in alcohol they fall to pieces as if they had been boiled."

164. THE SPECKLED TROUT—SALVELINUS FONTINALIS.

The following chapter is a reprint of Mr. Goode's essay upon the Speckled Trout, in Scribner's "Game Fishes of the United States":

The Speckled Trout must have been discovered at a very early day by the first settlers of

North America, yet, strangely enough, the only allusion to it in colonial times is in the 'Remonstrance of New Netherland,' addressed by that colony to the States General in 1649. It was first brought before the world of science in 1814, when Professor Mitchill named it *Salmo fontinalis*, a name which has become almost classical, and will be regretfully set aside for the more recent one, *Salvelinus fontinalis*.

DISTRIBUTION.—The Speckled Trout has its home between latitudes 32½° and 55°, in the lakes and streams of the Atlantic watershed, near the sources of a few rivers flowing into the Mississippi and the Gulf of Mexico, and in some of the southern affluents of Hudson's Bay. Its range is limited by the western foothills of the Alleghanies, and nowhere extends more than three hundred miles from the coast, except about the Great Lakes, in the northern tributaries of which Trout abound. At the south they inhabit the headwaters of the Chattahoochee, in the southern spurs of the Georgia Alleghanies, and tributaries of the Catawba in North Carolina. They also occur in the great islands in the Gulf of Saint Lawrence—Anticosti, Prince Edward's, Cape Breton, and Newfoundland. Temperature is of course the chief factor in determining the distribution of the species, and since few observations have been made in the field, our conclusions must needs rest on a study of the species in domestication, an instructive though not entirely reliable method. The experience of Messrs. Green, Stone, and Ainsworth, indicates that Trout cannot thrive in water warmer than 68° Fahrenheit, though they have been known to live in swift-running water at 75°. Fishes hatched in artificial ponds may probably be inured to greater warmth than wild fishes can endure, and it is doubtful whether the latter are often found in water warmer than 60° or 65°. At the Oquossoc and Cold Spring hatching establishments the water ranges from 45° to 49° throughout the year. Below 36° Trout are torpid and refuse to feed, and instances are on record of their reviving after being frozen stiff. The remarkable variations in the habits of Trout in different regions are easier to understand in the light of these facts. The identity of the Canadian Sea Trout and the Brook Trout is still denied by many, though the decision of competent authorities has settled the question beyond doubt. This being admitted, let us compare the habits of the Sea Trout and the Salmon. Both inhabit the ocean a part of the year; both ascend rivers to spawn; both change their sea-garb of silvery gray for the gorgeous crimsons, purples, and bronzes of the pairing season. Some Salmon, detained by barriers or by their own preference, become permanent denizens of fresh water, where they reproduce their kind, relinquishing their gray coloration, and assuming a brighter dress peculiar to themselves. Does not the analogy still hold out, and do not our Brook Trout correspond with the Land-locked Salmon? In the Long Island region Trout live in salt water in the coldest months, when its temperature is below 50°. North of the Bay of Fundy, at the entrance to which the water barely registers 50° in midsummer, they inhabit the ocean abundantly, except at the spawning time. South of New York the coast reaches of the rivers appear to present a barrier of warm water which the Salmon do not seek to penetrate from without, and which immures the Trout in their homes in the hill country as closely as would a mountain wall.

When Trout have no access to the sea they still contrive to avoid a change of temperature with the seasons. In midsummer they lie in the bottoms of lakes cooled by springs, in the channels of streams, or in deep pools, lurking behind rocks and among roots. In spring and early summer they feed industriously among the rapids. At the approach of cold weather in autumn they hasten to the clear shallow water near the heads of the streamlets. It is at this time that they deposit their eggs in little nests in the gravel which the mother-fish have shaped with careful industry, fanning out the finer particles with their tails, and carrying the large ones in their mouths. After the eggs are laid, the parent fish covers them with gravel, and proceeds to excavate another nest. The same nests are said to be revisited by the schools year after year.

SPAWNING HABITS.—Of the Trout Mr. Milner writes: "His whole wooing is the most polite attention and the gentlest of persuasions. He moves continually to and fro before his mate, parading his bright colors, while she rests quietly, with her head up stream, vibrating her fins just sufficiently to keep her from floating down. At Waterville, Wisconsin, I had the opportunity of watching their habits. A pair of large Trout had selected a spot near the bank of the stream, where the water was about ten inches deep. The female had fanned the gravel with her tail and anal fin until it was clean and white, and had succeeded in excavating a cavity. They were frightened away as I came to the edge of the bank. Concealing myself behind a willow bush, I watched their movements. The male returned first, reconnoitering the vicinity, and, satisfying himself that the coast was clear, spent a half hour in endeavoring to coax the female to enter the nest. She, resting half concealed in the weeds, a few feet away, seemed unwilling to be convinced that the danger was gone; and he, in his full, bright colors, sailed backward and forward from the nest to his mate, rubbing himself against her, and swimming off again in a wide circle close along the bank, as if to show her how far he could venture without finding danger. She finally entered the nest."

The spawning season begins in New England in October, continuing from three to six months, and during this period the fish should be protected by stringent laws. Mr. Livingston Stone observed that in his ponds at Charlestown, New Hampshire, spawning began October 12, and ended early in December; at Seth Green's establishment, near Rochester, New York, it began on the same day, and continued until March. At the former station spring water, with a uniform temperature of 47°, was in use, while at Caledonia the eggs were kept in brook water, which is colder in midwinter, retarding development.

Trout eggs are usually three-sixteenths of an inch in diameter, although varying greatly, and are colorless, red, or orange-hued. The quantity yielded by a fish is in direct proportion to its size, the average being from four to six hundred. Mr. Stone took sixty from a half-ounce fish, and eighteen hundred from one which weighed a pound. The eggs having been laid, their time of development depends strictly on the temperature of the water. According to Mr. Ainsworth, they will hatch in one hundred and sixty five days with the mercury at 37°, one hundred and three at 41°, eighty-one at 44°, fifty-six at 48°, forty-seven at 50°, thirty-two at 54°, etc. Seth Green's rule is that at 50° they hatch in fifty days, every degree warmer or colder making a difference of five days. After the eggs are hatched the yolk sac is absorbed in from thirty to eighty days, and the young fish begin to lead an independent life. Now the rate of growth is determined by the amount of food consumed. Some two-year-old fish weigh a pound, some half an ounce, as Mr. Stone's experiments show. In domestication growth is more even. Mr. Ainsworth's estimate allows an average of two ounces for yearlings, a quarter of a pound for two-year-olds, half a pound for three-year-olds, and a pound for four-year-olds. Wild fish often grow much faster. One of a large number of Rangely Trout, tagged by Mr. George Shepard Page in 1871, and caught in 1873, was found to have grown in two years from half a pound to two pounds and one-quarter. All two-year-old Trout and some yearlings can reproduce their kind.

SIZE.—The size attained varies in different regions. Brook Trout seldom exceed two or three pounds, and a five-pounder is thought a monster. Saint Lawrence Sea Trout usually weigh two and one-half pounds, though they are not seldom caught weighing six or eight. A famous locality for large fish is the headwaters of the Androscoggin River in Northwestern Maine. Professor Agassiz in 1860 obtained one of them which weighed eleven pounds. The well-known specimen taken by Mr. George Shepard Page in 1867, in Rangely Lake, weighed ten pounds after three

days' captivity, and was thought by experts to have lost a pound and a half in transit from Maine to New Jersey, where it died. Its length was thirty inches, and its circumference eighteen. Another, from Mooschuemaguntic, weighed eight and one-half pounds, and measured twenty-five inches. The Nepigon River claims still heavier fish. Hallock mentions one said to have weighed seventeen pounds.

VARIATION.—There are many local races of Trout; the same stream often contains dissimilar forms, and those bred in different hatcheries may easily be distinguished. Whoever has seen the display at the April opening of the trout season at Mr. Blackford's, in Fulton Market, New York, can understand the possibility of almost infinite variety in form and tint within the limits of one species. Fish inhabiting swift streams have lithe, trim bodies and long, powerful fins; those in quiet lakes are stout, short-finned, and often overgrown. In cool, limpid brooks, with sunlight, much oxygen, and stimulating food, their skins are transparent and their hues vivid; in dark, sluggish pools they are somber and slimy, and are called "Black Trout." Agassiz noticed that those of the same river varied accordingly as they haunted its sunny or shady side. They have the power of changing their tint at will. The influence of the nerves over color was neatly demonstrated by M. Pouchet, who produced a white side in a Trout by destroying the eye of that side. In the sea, for reasons unexplained, both Trout and Salmon lose their gay colors and become uniform silvery gray, with black spots. In the sea, too, the flesh assumes a reddish color, due no doubt to the absorption of the pigments of crabs and shrimps eaten by the fish. Red flesh is also found in some inland races.

CHARACTERISTICS.—Our Trout are strong feeders, but are dainty rather than greedy. They consume moderate quantities of food, and it suits their capricious appetites to seize their prey while living. They take objects at the surface with an upward leap instead of downward from above like the Salmon. Of all foods they prefer the worms washed out of the bank, then gayly colored flies, water insects, little fishes, larvæ, and the eggs of fishes. Those in domestication are usually fed on the heart, liver, and lungs of animals killed for the market.

Their daintiness, shyness, cunning, and mettle render them favorites of the angler, who lures them into his creel by many sly devices. The most skillful fisherman is he who places before them least obtrusively the bait which their momentary whims demand, or a clever imitation thereof. Trout are always in season from April to August, and in some States for a longer period.

CULTURE.—They have always been the pets of fish-culturists; indeed, the experiments of Dr. Garlick and Professor Ackley, who inaugurated in 1853 the practice of this art in America, were made with this fish. They become thoroughly domesticated, and are as much under the control of their owner as his horses and cattle. They have been acclimatized in England since 1868, and are always on exhibition in Frank Buckland's museum of fish-culture at South Kensington. The "Domesticated Trout," by Livingston Stone, and "Trout Culture," by Seth Green, are books which give full information concerning the practical details of trout-breeding.

The Trout can scarcely be considered a market fish; still, about five thousand pounds of them, mostly domesticated, are brought to New York market each year, principally in April and May.

165. THE SAIBLING, OR BAVARIAN CHAR—SALVELINUS ALPINUS.

Like the Red-spotted Trout of North America, the Saibling belongs to the division of the same family known to the English as "Chars," a group confined, for the most part, to fresh-water lakes and streams, and distinguished from the true Salmons by a peculiar arrangement of teeth on the

little triangular bone in the roof of the mouth known to anatomists as the "vomer," from its resemblance in shape to a plowshare.

The Chars are also distinguished from the Salmon by their very small scales, and usually by numerous crimson or orange-colored spots, which are especially conspicuous in the breeding season. The Saibling is, in its habits, perhaps more similar to the well-known Blue-backed Trout or Oquassa Trout of Rangely Lake, Maine, than to our Brook Trout. The Chars of Europe are, as a rule, lake fishes like the Saibling. On the other hand, the Chars of North America are usually found in streams and rivers, although the Oquassa Trout, just mentioned, and the Lake or Mackinaw Trout, which is apparently nothing but a giant Char, together with the closely related form the "Siscowet," resemble in their habits the Chars of Europe.

VARIATION.—There is probably no group of fishes in which individual specimens and communities inhabiting certain areas of water show more tendency to variation in color and form than they do in the salmon family. Dr. Günther has very justly remarked: "We know of no other group of fishes which offers so many difficulties to the ichthyologist with regard to the distinction of the species as well as to certain points in their life-history. Although this may be partly due to the unusual attention which has been given to their study, it has revealed rather a greater amount of unexplained fact than a satisfactory solution of the questions raised. The almost infinite variations of these fishes are dependent upon the age, sex, and sexual development, food, and the properties of the water."

No one who has ever seen the remarkable display of Brook Trout at the annual trout opening at Blackford's in New York can fail to have been impressed by the wonderful differences which exist between individuals of the same species from different localities—differences which lead an untrained observer, or even an ichthyologist who has had no experience in the study of this group to decide at once that several species were represented among the hundreds of specimens lying on the marble slabs.

The tendency of modern ichthyology, with its more exact methods, and with access to better and more comprehensive material for research than was formerly available, has led to the rejection of many of the nominal species formerly recognized. Out of the forty-three species of Salmon ten years ago believed to exist in North America, only thirteen or fourteen are now recognized. In Günther's catalogue of "The Fishes in the British Museum," published in 1866, thirty-one species of Chars were mentioned, while in his lately published "Study of Fishes" the same author ventures to enumerate only thirteen, all others being regarded as insufficiently characterized. In his treatment of the Chars of Europe, Günther is, notwithstanding, one of the most conservative writers, for he catalogues eight species of these fish, while most other European students, following the lead of the great German ichthyologist, von Siebold, regarded them as members of one polymorphic species. As for American ichthyologists, our sympathies are naturally with the school of von Siebold. It is difficult to believe, in the light of our own observations upon the salmon family in America, that every little lake or group of lakes in Europe possesses a well-characterized species of fish, and for the present it seems safer to consider the Chars of Europe to be of a single well-marked species which undergoes numerous variations under the influence of changes in temperature, elevation, food, and light, and that the Saibling of Bavaria and Austria is one and the same thing with the "Ombre Chevalier" of France and Switzerland, "Salmarino" of Northern Italy, the "Torgoch" of Wales, the fresh-water "Herring" of Ireland, the "Char" of England and Scotland, the "Röding" of Sweden, and the "Kulmund" of Norway.

DISTRIBUTION.—This fish, whether it be regarded as a single species or several related species, is distributed over all of Northwestern Europe, and possibly also over a portion of Asia, although, since the Asiatic representatives of the genus have not been sufficiently studied, it is impossible yet to make this generalization. They are, emphatically, cold-water fishes, thriving at a temperature little above the freezing point, and in their period of greatest vigor and perfection at the approach of winter, as is indicated by the fact that at this time their spawning takes place. No fish of any kind has ever been found nearer to the North Pole than the Char, a species, *Salvelinus arcturus*, having been discovered by the last English polar expedition in 12° north of the Arctic Circle. In the south of Europe its range is limited by the Alps, and in this region its study has brought to light a very curious fact which confirms still more strongly the idea just spoken of, that the fish thrive the best in a very cold climate. In the extreme north and in the extreme south this fish reaches its greatest perfection. The northern species, found everywhere in the lakes of the Scandinavian Peninsula and Scotland, is a fish sometimes, it is said, attaining a length of four feet. In England and France and in the lower lakes of Switzerland it is comparatively insignificant, while in the deep, cold Alpine lakes it often grows to two feet or more in length, and weigh ten or twelve, and even, in exceptional cases, twenty-four pounds. The highest development, however, seems to be attained in the largest lakes—like that of Geneva—while in the shallower lakes, higher up among the mountains, they are smaller. A similar phenomenon is exhibited by certain sub-arctic plants, which thrive in the extreme north and upon the summits of the Alps, becoming dwarfed or almost extinct in the lowlands between.

It is interesting, too, to compare the effect of temperature, and secondarily of elevation, upon the Saibling and upon our own Red-spotted Trout. This species has its home between latitude 32½° and 55°, in the lakes and streams of the Atlantic watershed, in the mountain sources of a few rivers flowing into the Mississippi and the Gulf of Mexico, and in some of the southern affluents of Hudson's Bay. In the north, for instance in the valley of the Saint Lawrence, it is common in the lowland streams and estuaries, and even in the adjoining parts of the ocean, and here it attains its greatest development. As we proceed farther south, in accordance with the limitations of temperature, its range becomes more restricted, and in Southern New England it is only at certain seasons of the year—at the approach of winter—that they find their way into the lowland streams which are in summer too warm to be endurable, and at other times they are found near their sources among the hills. On Long Island, however, they are still found in the meadows, and to some extent in the estuaries. Passing to the southward of New York, the natural southern limit of the Salmon, the range of the Trout becomes more and more restricted to the highlands; and although they are found as far south as latitude 33°, in the western districts of the Carolinas and the extreme northern part of Georgia, they there occur only at great elevations among the mountains of the Alleghany chain. South of New York they are effectually land-locked by the prevailing high temperature of the lowland streams, and are never able to gain access to salt or brackish water. Their supply of food is, consequently, limited, and they are confined to brooklets among the mountains. Although the temperature of this region is usually very favorable, other requisites for high development are lacking, and the species is represented throughout the southern part of its range by diminutive individuals. A similar phenomenon is met with in those instances where the European Char exists in the high and comparatively shallow mountain lakes of the Swiss and Austrian Alps.

In the southern part of its habitat the American Brook Trout finds its environment unfavorable to its perfect development; on the other hand, the European Char meets, in the Alpine

lakes, conditions precisely similar to those of the lakes of Norway and of Scotland, and under these favorable conditions has survived in a state of great perfection.

We have in the Great Lakes of North America a fish closely allied to the Chars, which, under remarkably favorable circumstances, with plenty of room and an immense supply of rich and easily attainable food, has developed into one of great size and commercial importance, the Lake Trout, and its cousin, the Siscowet.

RELATIONSHIPS.—The various Lake Trouts of Maine and Eastern Canada, found in the smaller lakes of those regions, are very similar to the European Char. The American species which, however, bears the closest resemblance to the European Char is, as has been stated, the Blue-backed Trout, or Oquassa Trout, of Rangely Lake, the Red-spotted Trout of the Pacific coast, *Salvelinus malma*, known also as the "Dolly Varden," being very similar in habits to the Brook Trouts of the East.

The resemblances between the Saibling and the Oquassa are as follows:

1. They inhabit the deepest waters of their lake home, and are never seen except at their spawning season.

2. They spawn late in the fall.

3. At the spawning season they come into shallow water near the shores, or in the mouths of streams, and may be taken with the greatest of ease.

4. They never willingly inhabit streams of running water.

These peculiarities the two species have in common, and, excepting the habit of autumn spawning, they share them with no other members of the family. The Saibling, however, is a much larger and finer species than the Oquassa, and it is hoped that it may be adapted for cultivation in many of the smaller lakes in which our Great Lake Trout is not likely to thrive. It is regarded as a very excellent food-fish, and is doubtless more delicate in flavor than the Lake Trout, sharing most of the excellent qualities of the Brook Trout.

HABITS.—The Saibling, which through the courtesy of the German Government is now being introduced into the United States, is the European Char in its highest state of perfection. The following account of its habits is translated from a sketch by Dr. Wittmack, of Berlin:

"The Saibling varies much in form, size, and color, according to its age, sex, and habitat. Those which come from the highest Alpine lakes are always small, but those in the lakes of Switzerland and Savoy have higher bodies, larger scales, and also a clearer color—yellowish-white, with red belly. This form was formerly considered distinct, and was known as the 'Ritter' or 'Knight' among the river Trout, the species which is found at the greatest height above the sea. In Switzerland, according to Tschudi, it is found at a height of 4,400 feet; in Bavaria, according to von Siebold, in the Green Lake, at the height of 5,000 feet; in the Tyrol, in the Gaislacher Sea, at the height of 7,000 feet, and in the Pleuderle Sea, at the height of 7,603 feet. In the Green Lake, as well as in other Alpine lakes, this is the only species of fish which occurs. It seems certain that it is found at greater heights in the eastern than in the western Alps, and is also more abundant. The breeding season occurs in the months of October, November, and December, and continues until February; for example, in certain lakes in Steiermark. In Lake Fuessen it occurs in October and November; in Lake Messkirch, where they are artificially propagated, in February and March; in the lakes at Saltzberg they spawn from November to January, and apparently also in February; and, in spite of the extensive fishery during the spawning time, there is no evidence of a decrease in their numbers. They feed upon small fish, and also, when at liberty, upon the small crustaceans, daphnids, and cyclopids. In the Alpine lakes these constitute their only food.

In Germany and in Austria it has been found that the Saibling is one of the most expensive fish to propagate artificially, on account of its food. The ordinary size of the Saibling is from eleven to twelve inches, and its weight from one-half to one pound. In the highest lakes they are, as has been mentioned, smaller, while when they are moved from such lakes into those that are deeper they increase rapidly in size. In the Saltzberg lakes, where they are taken upon certain spawning grounds from November to January, it takes about five of them to make a pound, but large specimens of three to twelve pounds are taken in August and September. In the Lake of Zug, which, according to Hoch, yields more Saibling than any other lake in Switzerland, it takes five or six, often eight or nine, to make a pound. In the Lake of Geneva they are often taken weighing twenty to twenty-four pounds. Herr Hoch himself saw one weighing seventeen pounds."

To this may be added a paragraph from Millet's "La Culture de l'Eau." "Itis very voracious, and, like the Trout, very swift and active in its movements. It habitually feeds upon small fishes, upon crustaceans, upon mollusks and insects, and in two or three years, under favorable circumstances, attains the length of fifteen to twenty inches. Its flesh is very delicate and savory, and it is preferred about Lake Leman to any other fish."

CULTURE.—The Saibling has been propagated by German fish-culturists for a period of ten years or more, and thrives magnificently in captivity. The hatchery at Oussee, in Germany, produces yearly three or four hundred thousand of artificially-brooded Saibling, and plants them in the neighboring lakes. In the tanks at the late International Fishery Exhibition in Berlin were exhibited many superb specimens of this fish, some of them over two feet in length, and one of these was sent to the National Museum by Herr von Behr, president of the Deutsche Fischerei Verein. It is as large as the famous Rangely Lake Trout caught by Mr. George Shepard Page, which everybody has seen at Blackford's in Fulton Market.

In selecting a place in which to deposit the saibling eggs just received, the Commissioner of Fisheries has endeavored to find a lake as similar as possible in depth and temperature to the larger Swiss lakes, and he has, therefore, sent them to Lake Winnipiseogee, N. H. Here the whole sixty thousand were planted, with the hope that by placing so large a number together in a lake of moderate size the experiment of introduction may be a success. It is a question of some interest which of the many European names of this fish should be adopted in the United States should the experiment of acclimation be a success.

It would seem most appropriate that, since the fish acquires its greatest perfection in Germany, the German name should be adopted, particularly since the German fish-culturists, who have so kindly made this gift to the people of the United States, will regard as a compliment the adoption of the German name of one of the favorite fishes of Germany.

166. THE DOLLY VARDEN TROUT—SALVELINUS MALMA.

By DAVID S. JORDAN.

This species is known in the mountains as "Lake Trout," "Bull Trout," "Speckled Trout," and "Red-spotted Trout." In the ocean, where it is found in large numbers, it is the "Salmon Trout." In the Sacramento the name "Dolly Varden" was given to it by the landlady at a hotel, and this name it still retains in that region. As none of the other names are distinctive, this one may well be adopted. In Siberia it was formerly known as the "Malma" or "Golet." The Indian name "Chewagh" is ascribed to it in British Columbia. In size this species reaches a weight of fourteen pounds. The largest I have seen weighed twelve pounds, which weight is not uncommon in the

ocean. In the lakes it averages smaller, and in the mountain streams it breeds at a length of six or eight inches. In all these peculiarities it agrees with its near relative, the common Brook Trout of the Atlantic coast. It ranges from the upper waters of the Sacramento to Kamtchatka on the west side of the Rocky Mountain chain, and for the most part in and west of the Cascade range. From Puget Sound northward it is generally abundant. It feeds voraciously in the salt water on smelt of various sorts, young Trout, sand lances, shrimps, anchovies, herrings, and even sticklebacks. In fresh waters it probably eats whatever living thing it can get. Nothing is certainly known of their breeding habits. They probably spawn late in the fall in the rivers, and therefore those which are in the sea must be to some extent migratory. They are taken in Fraser River at the time of the eulachon run, but they probably then ascend the river to feed upon the eulachon, and not for spawning purposes. As a food-fish this beautiful species ranks high.[1]

167. THE GRAYLING—THYMALLUS TRICOLOR.

The following essay upon the Grayling is quoted, in a modified form, from Goode's Game Fishes of the United States.

DISCOVERY.—The discovery of Grayling in Michigan and Montana was a surprise to American naturalists, though the areas to which this distribution is restricted are so small that one can hardly wonder at the delay in finding them out. The credit of discovering them is divided between Surgeon J. F. Head, United States Army, who found in 1860, in the headwaters of the Missouri, specimens of the form described by Milner in 1874, under the name *Thymallus montanus*, and Prof. Manly Miles, of Lansing, Michigan, whose specimens from the Michigan Peninsula were sent, in 1864, to Professor Cope, and described by him as *Thymallus tricolor*. A third species occurs in Alaska, and in the rivers emptying into the Arctic Ocean. This was first found by Capt. John Franklin's expedition toward the North Pole, in 1819, and called *Thymallus signifer*, by Sir John Richardson, who thus describes its discovery: "This very beautiful fish abounds in the rocky streams that flow through the primitive country lying north of the sixty-second parallel of latitude between Mackenzie's River and the Welcome. Its highly appropriate Esquimaux name ('Hewlook-Powak,') denoting 'wing-like,' alludes to its magnificent dorsal, and it was in reference to the same feature that I bestowed upon it the specific appellation of *Signifer*, or the 'standard-bearer,' intending also to advert to the rank of my companion, Captain Back, then a midshipman, who took the first specimen that we saw with the artificial fly. It is found only in clear waters, and seems to delight in the most rapid parts of the mountain streams." As is implied in these remarks, this species is remarkable for its immense dorsal fin, which is nearly twice as high as the body of the fish.

It is, however, the Michigan Grayling which is at present most interesting to the angler, the others being so remote as to be thoroughly inaccessible. Professor Cope's description was printed in 1865, but being expressed in technical terms, and published in the proceedings of a scientific society not generally read by sportsmen, it attracted little attention. Popular interest was first excited in 1873, by the discussions in "Forest and Stream," and by a letter from Professor Agassiz, published extensively in the daily papers, acknowledging the receipt of two specimens sent to him from New York through the agency of Mr Hallock, who had received them from Michigan. The subject was then taken up by the newspapers, and the Grayling was soon well known. A name closely associated with the study of the Grayling is the honored one of the late James W. Milner. In 1871, Mr. Milner, in company with Mr. D. H. Fitzhugh, of Bay City, Michigan, visited the Jordan River for the purpose of procuring specimens of this fish; but, although many

[1] For Pallas's account, see Günthe. vi, 144.

were seen in the clear cold waters, they could not be induced to take the hook during the day spent on the river. In 1873 he again visited this region, and subsequently published several popular articles on the subject of "Graylings of North America," which constitute one of the very few memoirs finished by him out of the many which were planned, and interrupted by his untimely death.

DISTRIBUTION.—His description of the habitat of the Grayling is excellent: "In the center of the Lower Peninsula of Michigan is a wide, elevated plateau, a sandy region, with a soil containing a very small per cent. of organic matter, and covered with a forest of pines, generally the Norway pine, *Pinus resinosa*, Linn., growing in grand dimensions, the long, limbless shafts making wide boards, free from knots, yet but little utilized, while immense forests of the favorite lumber material, white pine, *Pinus strobus*, are yet uncut. From this plateau arise several large streams and rivers, flowing each way into Lakes Huron and Michigan. Among these are three rivers of note, the Muskegon, the Manistee, emptying into Lake Michigan, and the Ausable, entering into Lake Huron. Among the minor streams are the Cheboygan, Thunder Bay, and Rifle, tributary to Lake Huron, and the Jordan, emptying through Pine Lake into the Traverse Bays of Lake Michigan. A few branches and streams, spring-fed, are formed, in which the water has a uniform degree of coldness throughout the summer, seldom rising above 52°. The rivers Rifle, Ausable, Jordan, Mersey branch of the Muskegon, and the headwaters of Manistee, all have this character, and in all of these, and only in this limited locality, short of the Yellowstone region, is found the already famous Michigan Grayling."

The town of Grayling, Michigan, formerly called Crawford, is in the midst of this district, and the headquarters of Grayling fishermen. The Grayling is said to live also in Portage Lake, in the extreme northern part of the State. These streams seem to be remarkably cold, being fed by numerous springs. Milner found the Ausable to vary between 45° and 49°, morning and evening, in September; and Mr. Fitzhugh has remarked that the south branch of this river, which rises in a swampy lake, contains no Grayling except near its mouth, where its volume is swelled by large springs, and its water becomes clear and cold.

The Grayling of Europe, *Thymallus vulgaris*, is also restricted to cold streams, and appears to be found within limited areas. It is found in Norway, Sweden, Lapland, and the Orcades, in Switzerland and Hungary, and southward to lakes Constance and Leman, and Bavaria. A Grayling, possibly of different species, occurs in Lake Maggiore, and others have been recognized from Russia and Siberia. It is constantly being discovered in new localities. In England the species was formerly known as the "Umber." "And in this river be Umbers, otherwise called Grailings," wrote Holinshed, in "The Description of Britaine," A. D. 1577. The German name, "Aesche," has been thought to refer, like "Grayling," to its color. The European and American fishes are so similar that only a trained ichthyologist can distinguish them, and their habits are very much the same. Our Grayling spawns in April in the Ausable, that of Europe in March and April, and sometimes, it is said, in May. Ours rarely grows to the length of sixteen inches, and the largest Milner could find weighed less than two pounds, the average length being ten or eleven inches, with a weight of half a pound. The European fish is said to grow to eighteen inches long, and the weight of four pounds and one-half. Milner remarks: "Like the Brook Trout, their natural food consists of the insects that light or fall upon the surface of the stream. Their stomachs were found to contain broken and partially digested specimens of coleoptera, neuroptera, as well as the larvæ of species of the dragon-flies. There were also found in their stomachs the leaves of the white cedar, *Thuja occidentalis*, which drop continually on the surface of the stream, and are probably taken because the fish in their quick darts to the surface mistake

them for insects falling upon the water." In France they are said also to devour little mollusks and the eggs of fishes.

CULTURE.—The propagation of the Michigan Grayling was attempted as soon as its existence was known. Mr. Fred. Mather and Mr. Seth Green, always pioneers in such enterprises, were the first to attempt it, and they were soon followed by others. Mr. Mather was first on the field, visiting the Ausable between March 25 and April 3, 1874; but he was too early, for the fish were not ready for him. Mr. Green followed on April 28, but he was too late, the fish having finished spawning. Not to be daunted, he dug over one hundred fertilized eggs out of the gravel where the fish had left them, and took them home to his hatching-house. In 1875 Mr. Mather visited the river between April 6 and 12, and obtained eight thousand eggs, which were successfully hatched. Young fish have been introduced into various streams in Michigan and Western New York. Frank Buckland tried many years ago to introduce the English Grayling into the Thames by transplanting its ova, but this experiment was a failure, and we have yet to learn that his American associates have been more successful in their efforts. An interesting fact observed in the course of these experiments is that the Michigan Grayling is much more prolific than the Brook Trout, yielding between three and four thousand eggs.

There has been much discussion over the claims of the Grayling as a game-fish, and also its excellence for food. It has many ardent admirers and detractors. The enthusiasm with which it was greeted ten years ago has somewhat subsided, and it seems doubtful whether a vote of the guild of American anglers would now place it in the first rank of noble fishes.

"There is no species sought for by anglers that surpasses the Grayling in beauty. They are more elegantly formed and more graceful than the Trout, and their great dorsal fin is a superb mark of loveliness. When the well-lids were lifted, and the sun's rays admitted, lighting up the delicate olive-brown tints of the back and sides, the bluish-white of the abdomen, and the mingling of tints of rose, pale blue, and purplish-pink on the fins, they displayed a combination of colors equaled by no fish outside of the tropics."

Mr. Mather describes the colors of the Grayling as follows: "His pectorals are olive-brown, with a bluish tint at the end; the ventrals are striped with alternate streaks of brown and pink; the anal is plain brown; the caudal is very forked and plain, while the crowning glory is the immense dorsal. This fin rises forward of the middle of the back, and in a fish a foot long it is nearly three inches in length and two high, dotted with large, brilliant-red or bluish-purple spots, surrounded with a splendid emerald green, which fades after death—the changeable shade of green seen in the tail of the peacock."

168. THE LAKE WHITE-FISH—COREGONUS CLUPEIFORMIS.

FROM NOTES OF LUDWIG KUMLIEN AND OTHERS—BY R. I. GEARE.

NAMES.—With the exception of the local name "Otsego Bass," said to be applied to this fish about Otsego Lake, New York, we have never heard any other name for it than "White-fish." It is found in all the Great Lakes, as well as in several of the smaller lakes tributary to them, and in lakes of British America northward, perhaps as far as the Arctic Ocean. It is very abundant, and is the most important food-fish of the Great Lake region. In quality of flesh it stands pre-eminent among our fresh-water fishes. The flesh is white, tender, and juicy, and, unlike the flesh of the Salmon, it does not produce satiety.

SIZE.—The largest specimens of White-fish are found in Lake Superior, one having been taken at White-fish Point weighing twenty-three pounds, and at the same place out of seventy-four half-barrels there was not one under six pounds in weight. At Duluth, White-fish weighing

from twelve to sixteen pounds are occasionally taken. Their average at the extreme west end of the lake is less than at the Apostle Islands, where some very large fish are caught. At Grand Island the fish average fourteen pounds, few being taken weighing less than ten pounds. In Green Bay, Lake Michigan, it is no uncommon occurrence to catch with deep nets fish from four to seven pounds, and in one lift there were twenty that exceeded five pounds, and some weighed eight pounds. About ten years ago a White-fish weighing nineteen and three-quarters pounds was taken near Menomonee. The Cisco, a variety of White-fish, in Green Bay attains a weight of three pounds; this is sometimes called the "Menomonee White-fish."

Next, in respect to the size of its White-fish, is Lake Michigan. On the west shore, where large fish are usually taken, in the vicinity of Manitowoc, a White-fish weighing twenty two pounds was taken in 1880. At the south point of Lake Michigan, the average weight is a pound and a half. Thirty-three hundred of that average were taken out of thirty gill-nets at one lift. The largest specimen ever taken here weighed fourteen pounds dressed. At Grand Haven, on the east shore of Lake Michigan, White-fish average about two pounds. Higher up on the east shore they are again larger, and average about ten pounds each in weight.

Lake Erie contains White-fish weighing as much as fourteen pounds. In the vicinity of Maumee they are larger than at any other point on the lake. In 1876 a seventeen-pound fish was taken at Vermillion, Lake Erie; and in 1879 one weighing sixteen pounds was captured. They are often taken weighing ten and twelve pounds. Farther east the average size becomes smaller, the season's average weight for White-fish at Ashtabula, Ohio, being not more than two pounds and a half. Farther to the east they are smaller still, and in the Detroit River they do not exceed a pound and three-quarters average weight.

In Lake Ontario White-fish average two and a half pounds for those taken in gill-nets, while those taken in seines will not exceed two pounds.

In order to ascertain the rate of the growth of the White-fish, Mr. George Clark tried an experiment to which he called the attention of the Detroit fishermen in the following words:

"ATTENTION, FISHERMEN."

"The 14th of May last I marked a number of White-fish with brass tags and put them into the Detroit River. The tags were a piece of brass about the size of a ten-cent piece, and a ring about the same size, and a similar ring linking these two together. The largest ring I put in the small fin on the back of the fish near the tail, each fish weighing about a pound and a half, the object being to ascertain the growth of the fish.

"Fishermen, one and all, if you catch any of these fish, will you please state when and where caught, weigh and measure length, and send them with the tags to Crowel & Co., S. John and Buck, of Toledo; the Paxtons, of Monroe; James Craig, A. M. Campau, C. Hurlburt and J. P. Clark, of Detroit; B. Reaume, of Springwells; George Clark, of Ecorse; Mr. Reaume, of Grosse Isle.

"I hope the fishermen on the Canadian shore will take an interest in this matter, and, if they catch any of these fish will please send them with the abovesaid specifications to the aforesaid parties, or to Davis & Co., and Merrill, fish dealer, in Detroit, or George Clark & Co.'s fish house, Detroit.

"If the fish cannot be sent, please send the exact weight and length of the fish, with the tag, by mail, to any of the above parties.

"GEORGE CLARK.

"ECORSE, *October* 9, 1872."

Mr. Clark never heard anything from these marked fishes.

On the same point Mr. Clark, writing to Professor Baird in March, 1872, says: "In June, 1868, I made a sweep with a seine, eighteen miles from the outlet of Lake Huron, on the shore of the lake, and caught at one sweep fish from three or four inches to twenty inches in length. Some of the largest fish weighed fifteen pounds. I concluded that they would increase in weight from three-fourths of a pound to a pound each year, which would require ten or fifteen years for the fish to get its growth. . . . He [speaking of Mr. Wilmot of the Wilmot Fishery Company at Newcastle, Ontario, Canada] has some White-fish two and a half years old last November, from some eggs which he procured here. The largest would weigh one and a half pounds. From this we judge the fish will gain in weight from one half to three-quarters of a pound each year."

MIGRATIONS.—Relative to the movements of the White-fish in Lake Superior, Mr. George Barnston is of the opinion that the young and immature White-fish confine their range entirely to shallow waters near the shore. The pound nets, set in twenty to forty-five feet of water, catch great numbers of small fish—seven or eight inches long and weighing only a few ounces. The gill-nets, usually employed in water not less than seventy to ninety feet deep, capture very few of these small White-fish. In a tour of Lake Michigan not one case of such small fish being captured in a gill-net—scarcely any under one pound—occurred. Again, a pound-net set on a thirty-six-foot shoal, six miles from land, at Bay de Noquet, contained only Nos. 1 and 2 fish. It might be urged that the small fish escape through the meshes of the gill-net; yet it is more than likely that occasional ones, entangled about the body and fins, would be taken, it being conceded that the head of the White-fish is to a slight extent better guarded against entanglement in the mesh than that of its congeners, the Lake Herring and the Cisco. Again, it is a significant fact that no young White-fish are found in the stomachs of the Lake Trout. The range of the Trout in summer is in deep water, and, if the young White-fish were there also, the Trout would surely feed on them. The conclusion of Mr. George Barnston, then, is that White-fish do not migrate at all into deep water until they have attained a weight of one and one-fourth pounds. He also corroborates Major Long's statement, that White-fish ascend Michipicoten River, Lake Superior, to spawn; "but," he says, "they cannot and do not run up far, for very high falls and long sweeps of raging rapids obstruct their course in both the main river and its tributary, not far from the Great Lake. Half a mile above the station I have assisted in seining White-fish at the spawning season, and succeeded occasionally in making a good haul. These fish must have come from the bay or lake, for they could never have descended the falls in safety, and the native fishermen (in all such cases good judges) consider them lake fish."

The line of migration followed by this fish in Lake Michigan is unerring and sure, and it is more apparent at the south end of Lake Michigan than at any other point on the lake; in the spring they always come down the east shore, and in the fall the west shore. About Point au Sable the runs begin in June and finish by the end of July, commencing again in September and continuing more or less throughout the winter.

During the last six years the White-fish are supposed to have changed their route of migration in the vicinity of Vermillion, Lake Erie. The spring run here comes in May and the fall run in October. The runs of the White-fish by no means occur simultaneously at all fishing points on Lake Erie, for the fishermen, at different points, are fishing for them as soon as the ice disappears in the spring, and continue until the ice comes again. The height of the runs may generally be considered as occurring during May and the fore part of June. Thence on until the end of July may be called the slack time, after which the fishing again becomes good, and continues to be so until the end of September.

In the spring the fish work from the west end of the lake and hunt for a certain depth of

water, remaining at their chosen spot until August, when they strike shorewards. Off Erie, Lake Erie, the water is shallow, and the fishermen are obliged to go out six to fifteen miles for White-fish; but off Dunkirk and Barcelona the water is deeper, and consequently shorter trips from land will suffice for fishing. This tends to show that White-fish are lovers of deep water.

In Lake Ontario, about Port Ontario, it is probable that the White-fish migrate from the Canadian shore to the American shore regularly. In 1870 they were more plentiful on the American shore; ten years before that, again, the reverse was the case. In 1880, following the rule, they have been scarce on the American shore, but will probably in a few years migrate again to this side of the lake. At Kingston Harbor they occur regularly. They have been known to run twenty miles up the river at this point; this is, however, unusual. Sometimes all the "Gray Backs" are found on the Canadian shore just before the regular spring run of the White-fish comes on. They are nowhere abundant on the American shore.

Mr. Peter Kiel, fishery overseer, Lake Ontario, says that White-fish are caught in early spring at a considerable distance from the shore in about two hundred feet of water, but about the 1st of June they approach the shore, and are then caught in great numbers on their favorite feeding grounds, a sort of honey-combed rock, in about thirty feet of water. About the 1st of August they retreat hastily toward the deeper and cooler portions of the lake, where they are found in their best condition. About the middle of October they again swim shoreward for the purpose of spawning, arriving at the proper locality from the middle of November to the 1st of December, depending upon the severity or mildness of the season, for they do not deposit their spawn until the water has attained a temperature of about 40° F. After spawning they again retire to the deep water, remaining there until the next spring.

Mr. Milner has contributed the following facts regarding the movements of the White-fish in the Great Lakes. From his observations it will appear that the migration shoreward is dependent upon the locality; depth of water, temperature, etc., are points which must be taken into consideration. Thus, in Lake Michigan, the summer migration into shoal water seems to be almost universal, while in Lake Erie, where the temperature is high in summer, the shoreward summer migration is unknown.

"The assertion was sometimes made among the fishermen that the scarcity of White-fish at any one locality was no reliable indication that the number had decreased, but that the schools had probably migrated to some other region.

"At Waukegan, Illinois, the White-fish come into shallow water in the greatest abundance in the months of June and July. The same habit is observed in various localities on the lakes, though by no means at all points. Several points on the shores of Lake Michigan, in the south half of the lake, the vicinity of the Apostle Islands, Lake Superior, and at the Thunder Bay Islands of Lake Huron, may be referred to as localities where the July migration occurs. George Keith, esq., a factor of the Hudson Bay Company at Michipicoten, in 1840, affords Sir John Richardson the same information upon the habits of a species of the *Coregonus*. It was for a long time a difficult matter to discover the reason for this summer run on the shore, if indeed it has been correctly accounted for. The contents of the stomach were found to be the same as at other seasons of the year. It was not probable that the White-fish was an exception to all its congeners of the salmonoid family, and preferred the warmer temperature of shallow water to the colder waters outside. Besides, the schools of White-fish were always found to leave a region where wide areas of shoal water existed as the heat of summer advanced. The theory adopted to account for this summer visit to the shore was that the calm, quiet weather of the summer months, from the slight disturbance of the surface, prevented the amount of aëration to the water that occurred at

other seasons of the year, and the fish sought the shore where the splashing on the beach and sand-bars supplied the water with the requisite amount of air, just as other species of this family of fishes delight in rapids and falls, because the breaking up of the masses of water supplies it with a large amount of respiratory gases.

"In waters like Lake Erie, where, according to the Lake Survey, the temperature attains as high as 75°, the White-fish seek the cooler deep waters in the summer, and I have not learned of a migration upon the shore at any point, they, perhaps, preferring a less amount of aëration to a high degree of heat.

"The fact that in the month of August the White-fish of the Sault Ste. Marie Rapids leave the river entirely, and do not return until in September, weakens the force of the theory that the aëration of the water is the necessity that brings them to the shore of the lake in the summer.

"Professor Agassiz, in his tour of the north shore of Lake Superior in 1849, found the White-fish scarce along the shore and at the rapids in the month of August. Among the Apostle Islands, Lake Superior, and in most of the deeper portions of the lakes, no scarcity is observed at this season of the year. At the rapids, they so entirely abandon the locality in August that the supply of fish for the hotels has to be obtained from Point Detour, at the head of Lake Huron.

"It was a disputed point among the Waukegan fishermen whether the migration was directly in from deep water or along the shore. The fact that, in some instances, the schools of fish struck the nets at one point, and afterwards entered the nets in succession along the line of the shore, was thought by many to prove a littoral migration. But the fact was that, in all likelihood, the advance portion of a school would touch the shore at some point and then move in either direction along its line.

"The presence of large White-fishes in numbers at certain localities on the north shore of Lake Michigan, of a size that are never taken at other parts of the lake, would indicate a local habit, with no disposition to range through long distances. Another observation sustaining the probability of this is the fact that there are many localities on the Lakes where the pound-nets, a few years ago, found prosperous fishing, and in the first few years took the White-fish in great abundance, but found afterwards a decrease from year to year until the locality was abandoned, while fifty miles away the business still continued successful. The well-known local instincts of the Salmon would, to a slight extent, confirm the probability of like instincts in its related genera. The fact that certain types of the White-fish are peculiar to particular localities, as the north shore of Lake Michigan, the Sault Ste. Marie Rapids, Bachewauna Bay, on Lake Superior, indicates a local habit through many generations until certain characters of a race have become established. The same fact has been stated for the shad on the Atlantic coasts. Some observations, made in 1871, perhaps indicate the opposite of all the foregoing statements.

"In the early part of the season there had been very few fish caught on the west shore of Lake Michigan, between Chicago and the Door Islands. South of Chicago, at the mouth of the Calumet River, the run of White-fish was in excess of anything had for years. But, about the 15th of June, the schools of fish left Calumet, and a few days later there was a decided improvement in the catch at Evanston. About June 22, the lifts at Waukegan began to be heavier than they had been before. During the first week of July the fishing was observed to improve at Milwaukee, Manitowoc, and Bailey's Harbor, and, a little later, at the Door Islands. The coincidence in dates rather indicated a probability that the same schools of fish that clogged the nets at Calumet during six or seven weeks had ranged northward along two hundred and sixty miles of coast. Still, the effect on the fishing would have been the same if it had been the migrations of schools of fish from deep water at these points in to the shore. In order to obtain a definite knowledge of

their habits in this particular, metal tags, with numbers indicating the locality, were distributed to fishermen at twenty points along the lake, to be fastened to the fins of live fish, which were then to be released. Instructions were at the same time sent to all fishermen to report the capture of fish bearing these marks, and the distances from where they were taken to the point of departure would indicate the extent of their migrations. It is thought that but few of them were used. A similar proceeding was afterward carried out by Mr. George Clark, of Ecorse, on the Detroit River, but none of the fish were ever heard from.

"Some of the fishermen of the west shore assert that, after severe storms encroaching on the shore, and making the water muddy for a long distance out, when the storm subsides there is a heavy deposit of mud on the bottom, and that the White-fish abandon the locality for a time, because, as they surmise, their food is buried in the sediment. On the contrary, after ordinary storms, there is generally an improvement in the catch of fish, probably for the reason that the great aëration of the water renders them lively and incites them to move about. The migration from the southern portion of Lake Michigan is of yearly occurrence, about the middle of June, and is, without doubt, occasioned by the large extent of shoal water becoming heated. The same thing occurs in Green Bay, and in the shoal regions of the western end of Lake Erie. The migrations into shallow water, and up certain streams, in the fall of the year, for the purpose of spawning, will be considered further on. This migration, and the summer visit to the shore, are the general migrations peculiar to the White-fish, while the departure from shoal regions in summer, and from certain localities in August, are local peculiarities."

ENEMIES.—This section of the natural history has been fully worked up by Mr. Milner in his "Report on the Fishes of the Great Lakes," from which the following extracts are made:

"The largest percentage of destruction the White-fish suffers is without doubt in the ova stage. The spawn-eaters of the Lakes are a numerous and widely distributed list of animals, including fishes, amphibians, and, it is claimed, divers and ducks. The destruction of the spawn by these methods is immense, and far exceeds the losses while in the stage of fry. The most wholesale devourer of the eggs is undoubtedly the Lake Herring. On opening the stomachs of the Herring from the ponds in Detroit River, in November, they were found to contain the eggs of White fish. At first it was considered possible that, as they were confined in the ponds, their eating spawn might be a matter of necessity; but later, at Sandusky, their stomachs were found gorged with the ova. The Herring, the most numerous species inhabiting the spawning grounds of the White-fish, are without doubt the principal agents in keeping in check the increasing numbers supplied from the fertilized ova. The suckers, sturgeon, and smaller bottom-feeding fishes are found with spawn in the stomach.

"The so-called 'water-lizard,' *Menobranchus lateralis*, Say, is very numerous in some of the streams and portions of the lake shore. Mr. George Clark, of Ecorse, Michigan, had a minnow-seine fitted to the bag of a sweep-seine, and at one haul took two thousand of the 'water-lizards.' Estimating the extent that the net had passed over, he calculated the average number of lizards to each square rod to be four. He says, further, in one of the Detroit papers, 'The lizards were so gorged with White-fish spawn that when they were thrown on the shore hundreds of eggs would fly out of their mouths. . . . Some of the larger lizards would devour the whole spawning of a White-fish in a day or two; and when we consider that these reptiles are feeding upon eggs from November till April, some idea may be formed of their vast capacity for destruction.'

"Mr. Browne, of Grand Haven, Michigan, states that some three years ago an epidemic seemed to prevail among the *Menobranchi* in Grand River in the mouth of June, and that their dead carcasses were washed ashore by hundreds, so that they lined the banks of the river, and

the millmen were obliged to throw the bodies off into the current, to be carried down stream to prevent the offensive stench that was wafted into the mills from the decaying remains.

"A fisherman at Evanston, Illinois, a few years ago had nine hundred hooks set in the lake, and in one day took from these five hundred lizards, removing them all himself, as his men, sharing the popular notion on the Lakes, believed them to be poisonous, and preferred to cut away hook and all to taking hold of the slimy amphibian. They are, of course, entirely harmless in this particular, and make no more attempt to bite than a frog does. A full series of this species was this season collected from Detroit River, from the length of one and one-fourth inch to thirteen inches. Later, about the middle of the month of July, Mr. George Clark collected a quantity of their eggs, proving this month to be the spawning season of the animal.

"The sturgeon are very generally believed to be spawn-eaters. Though the ova of the White-fish and the perch have been observed among the stomach contents of this fish, the principal food has always been found to be snails, the fresh-water genera being generally represented, the weaker shells crushed into fragments, and the stronger ones of the *Paludinidæ* and even *Limneas* remaining unbroken. Dr. E. Sterling, of Cleveland, who examined the stomachs of a large number of sturgeon in the vicinity of the Sandusky fisheries, made the same observation. There are few of the bottom-feeding fishes but whose stomachs will not generally be found to contain a few eggs, though in company with other food in greater quantity.

In the fry stage they must suffer to some extent from the piscivorous fishes. The most numerous and voracious of their enemies is likely to be the wall-eyed pike, *Stizostedion americana*, numerous in the shoal waters of the lakes and comparatively rare on the deeper shores. The perch, *Perca flavescens*, are very generally distributed and quite numerous; the contents of their stomachs are generally found to be vertebrate forms. The black bass, *Micropterus nigricans*, is plentiful in Lake Erie, but as its ordinary food is the crawfish, where these are numerous its depredations on the schools of young fish would be of comparatively little importance. The white bass, *Roccus chrysops*, the muskellunge, *Esox nobilior*, and the lake pike, *Esox lucius*, do not inhabit the Lakes in sufficient numbers to be very troublesome to the White-fishes. It is the prevailing idea on the Lakes that the Mackinaw or Salmon Trout feeds largely on the White-fish. Here as everywhere civilized man disturbs the balance of nature, and becomes the great enemy to all forms of life that do not conform to his artificial methods for their protection. Not only by the hundreds of artifices for the capture of the White-fish, but in the foul drainage from the cities, smelting-works and manufactories, and in the quantities of sawdust from the mills, they are driven from their favorite haunts and spawning grounds, and their food destroyed by waters tainted with fatal chemical combinations."

Mr. Milner mentions the natural casualties of storms, deposits of sediment smothering the eggs, the vegetable growth found to be so fatal in the hatching troughs, as causes of destruction to immense quantities of White-fish spawn.

Mr. Lanman, speaking of the enemies of the White-fish, says that the great Gray Trout (*Salmo ferox*) follows the White-fish to the shore and preys upon it. While the nets are set for White-fish, the fishers, with torch and spear, attack and capture the *Salmo ferox*, frequently of large size; and hence this latter fish has acquired the name of *Tuladi* from the river to which it is attracted by its favorite prey.

FOOD.—Mr. Milner, in his "Report upon the Fisheries of the Great Lakes," wrote the following paragraphs on the White-fish:

"The food of the White-fish has been a problem inciting numerous conjectures among fishermen, sportsmen, and fish-culturists, and baffling the investigation of a few naturalists for a number of years past. To Dr. P. R. Hoy, of Racine, we think, belongs the credit of first

discovering correctly the character of their food. On opening the stomachs of numerous White-fish he at first failed to determine the character of the stomach contents, until, after washing the half-digested mass in a basin of water, he found the sediment to be full of small *Crustacea*, whose existence in the lake had never before been suspected. My examination and preservation of the stomach contents from all quarters of the Lakes confirmed Dr. Hoy's observations, and discovered a few other small forms of life as the food of White-fish. The invertebrates found were of crustaceans: species of the families *Gammaridæ* and *Mysidæ*; of the mollusks: species of the genus *Pisidium*; and certain insect larvæ. A few fish-ova were frequently found in the stomach, and it was not unusual to find a little gravel.

"In the greater portion of the lake the *Gammaridæ* constituted the principal food. In shallow regions small *Conchifers* were more numerous. At Point aux Barques, on the north shore of Lake Michigan, where a very large type of the White-fish was found, the stomach contents were entirely of the *Mysis relicta* Loven. In the Sault Ste. Marie Rapids, in July, a mass of small chrysalides was found in the stomachs of a number of White-fish. In October, from the same locality, the larvæ of the caddis-fly were found in the stomachs, apparently carefully separated from their artificial coverings. Stomachs opened in Lake Superior contain principally the *Mysidæ*. At Rocky Island, in the northwestern part of Lake Michigan, a vessel with a cargo of wheat was lost a few years ago. The fishermen say that White-fish were taken in that vicinity for several years afterward with wheat in their stomachs.

"Rarely White-fish will take a bait. The breakwater protecting the Illinois Central Railway at Chicago was formerly a favorite fishing place, and in early summer was often lined with a row of boys and men fishing for perch. There was seldom a day passed but that a few White-fish were taken. Mr. Trompe, of Sault Ste. Marie, has frequently taken them in that locality with a hook baited with a May-fly, *Ephemeridæ*. At a fishing dock on Sand Island, one of the group of the Apostle Islands, Lake Superior, there were a few taken this season with a worm bait.

"The leech, *Ichthyobdella punctata*, Smith, parasitic on the White-fish, and numerous in some localities, was in no instance found in the stomach. This corroborates Dr. Hoy's observations. A similar fact was noticed afterward at Detroit River. A parasitic crustacean, a *Lernæa*, was found adhering to the White-fish in numbers, and, though many stomachs were examined, in no instance were any of the parasites found in the contents. Both the *Lernæa* and the *Ichthyobdella* are related to species made use of as food by the White-fish, as near in the one instance as being in the same class, and the other in the same order. The mouth is constructed for nibbling along the bottom, the opening being directed nearly downward, and they gather in the small life of the bottom and the gravel as they move slowly along.

"Dredging in the lake at different localities and examination of stomach contents at numerous points prove that the crustaceans and the mollusk constituting the principal food of the White-fish are distributed throughout the lake bottom, in all localities, and at all depths over about twenty fathoms. In Torch Lake, a deep inland lake in the Grand Traverse region, Michigan, where a large type of White-fish is found, the dredge brought up the same species of crustaceans and mollusks as were found in Lake Michigan. The failure to find food in the stomachs of White-fish has frequently resulted from the fact that the fish examined were taken from the pound-nets, where they had remained long enough to digest the contents of the stomach before they were taken from the water. Fish from the gill-nets have generally the food in the stomach only partially digested, while a hundred fish in succession from the pound-nets may be opened and every stomach found empty.

It is frequently asserted that aquatic vegetation afforded sustenance to the White-fish. The

investigations in the past two years did not result in any confirmation of this notion, and it would not accord with the habits of any species of the family of fishes to which the lake White-fish belongs."

A list of the precise contents of the stomachs of individuals examined by Mr. Milner is now appended:

"Specimens from Outer Island, Lake Superior, contained great quantities of *Mysis relicta*, *Pontoporeia Hoyi*, and *Pisidium abditum*, var. *abyssorum;* and with these were a few specimens of dipterous larvæ of the genus *Chironomus*, a small worm (*Lumbricus lacustris*), *Daphnia galeata*, *D. pellucida*, and a small species of *Planorbis*.

"From Sand Island, Lake Superior, *Pontoporeia Hoyi;* larvæ and pupæ of *Chironomus;* *Valvata sincera*, and *Gyraulus parvus*.

"From Sault Ste. Marie, one lot contained scarcely anything but small shells. Among these, *Valvata tricarinata*, *V. sincera*, var. *striatella*, *Amnicola generosa*, *A. palida* (?), *Gyraulus parvus*, and a species of *Limnæa* were in abundance; while there were fewer specimens of *Goniobasis livescens*, *Physa vinosa* (?), young, *Sphærium striatinum*, and *Pisidium compressum*.

"Other specimens contained nothing but the remains of insects, among which were the imagos of two species of *Diptera;* larvæ and pupæ of *Chironomus;* larvæ and pupæ of some specimens of *Ephemeridæ;* great numbers of the larvæ, pupæ, and subimagos of a species of *Hydropsyche*, and the larvæ of a species of some other genus of *Phryganeidæ*.

"From Ecorse, Michigan, specimens contained a species of *Hydrachna*, the leg and the scales from the wing of some lepidopterous insect, and a species of *Limnæa*.

"White-fish which I examined at Isle Royale, in August, 1871, contained scarcely anything but *Mysis relicta* and *Pontoporeia Hoyi*.

"Ecorse, Michigan—remains of a small fish and several specimens of a species of water-boatmen (*Corixa*).

"Specimens of *Coregonus quadrilateralis* from Madeline Island, Lake Superior, contained a number of specimens of a leech (*Nephelis fervida*) and a neuropterous larva allied to *Perla*.

"These few observations are sufficient to show that the White-fish, like the different species of Trout, feeds on a large number of species belonging to very different groups of animals. In this brief enumeration, twenty-five species are mentioned—nine of insects, four of crustacea, one worm, and eleven of mollusks; and these are undoubtedly only a small part of the species upon which the White-fish really feeds."

Much difficulty was experienced by Mr. Milner in his attempts to discover the food required for the sustenance of some young White-fish which had been sent to him. His experiments, together with a letter written to him by Mr. Briggs, editor of the "Lens," Chicago, with regard to the contents of the stomachs of embryo White-fish, are here reproduced:

"*Food of embryonic White-fish.*—The young fish reached Waukegan in safety, and were placed in five-quart glass jars, and an experiment begun in attempting to supply them with suitable food. A numbered label was pasted on each jar, so as to keep them distinct. Knowing that the larger White-fish fed largely on crustaceans, an attempt to feed them on food of this character was thought worth a trial. A few crawfish were procured and pounded to a paste, and small portions put into jar No. 1; the young fish ate it readily. They were fed at night, and the next morning every one of them was found to be dead. Jar No. 2 was supplied with bread-crumbs, and the fish were seen to take small particles in their mouths; they did not die so suddenly. Jar No. 3 was supplied with sweet cream, but no evidence was afforded that the occupants fed upon it. A quantity of rain-water was exposed to the rays of the sun for the purpose of generating minute forms of life, and a teaspoonful was poured into jar No. 4, morning and evening, in hopes that

their proper food was of this character. In jar No. 5 a variety of food was provided, dry fresh beef, milk, boiled potato, and bread. The crumbs of bread and the scrapings from the beef were all that the fish were seen to take into their mouths. They died, one after another, very rapidly, and in a few days all were dead.

"*There were other things unfavorable to them, in these experiments, besides the lack of their* natural nourishment. To conduct these experiments favorably, they should be placed in a large vessel, and a stream of fresh water should be supplied constantly so that the water should continue pure and the production of confervæ be avoided. This difficulty of procuring a suitable food for the young White-fish has been the experience of the few fish-culturists who have hatched them.

"A set of specimens, representing young fish from the Detroit River, from the troughs at Clarkston, and from the jars, were preserved in alcohol and submitted to Mr. S. A. Briggs, editor of the 'Isens,' Chicago.

"A letter from Mr. Briggs contained the following:

"CHICAGO, *May* 28, 1872.

"MY DEAR SIR: The four vials containing *C. albus* came duly to hand, and have, with the alcohol and water in which the specimens were preserved, been carefully examined.

"The intestines of specimens Nos. 77 and 78 from Clarkston were entirely destitute of organic matter recognizable under a power of 400 linear, which ought to be ample for the purpose. Those of specimens 76 and 79, from Detroit River, contained numerous specimens of two species of *Diatomaceæ*, viz, *Fragilaria capucina and Stephanodiscus Niagaræ*. The former is a filamentous form which grows very abundantly in our lake inlets attached to stems of lilies. The latter is a large form which, from its peculiar build, contains considerable nutritious material.

"Very sincerely, yours,

"S. A. BRIGGS."

Two statements of a more general character are made regarding the food of the White-fish in Lakes Erie and Ontario; the one, an extract from a letter by Mr. John W. Kerr, Hamilton, Ontario, the other by Mr. Peter Kiel, of Wolfe Bay:

"The White-fish at this season of the year, fall and winter, feed on small shell-fish. This you can ascertain yourself by analyzing the contents of their stomach. In spring and summer they feed on a kind of shrimp-like insect; and from my knowledge and experience I have never known them to change to any other kind of food than those two kinds now described to you by me."

"The White-fish is of a fine organism, and, being entirely destitute of teeth, is neither predaceous nor yet very voracious in its nature, but lives on the most simple fare, which consists principally of small worms and insects that abound in great numbers among the plants and porous rocks on the bottom."

SPAWNING AND DEVELOPMENT.—The most elaborated discussion of (*i*) the habits of the White-fish at the spawning season (noted day by day in the journal of the author), concluding with a table showing the relative weight of ovaries and number of eggs in proportion to the weight of the fish, (*ii*) the development of eggs and embryo, and (*iii*) the rate of the young White-fish's growth, has been written by Mr. Milner in his "Report on the Fisheries of the Great Lakes," and is here given in full:

(*i*) *The habits at spawning season.*—"The White-fishes throughout the larger portion of the Lakes, come into shallow water to deposit their spawn about the middle of November, just at the time when the Salmon Trout has finished spawning and is returning to deep water. At this

season they come in from deeper water in vast schools, and are taken in large quantities by the nets. A notion, prevalent among the fishermen in some localities, that the female fishes arrived first, and were followed, a few days later, by the male, was not confirmed by my observation. The bottoms on the spawning grounds vary in character in different localities; rock, sand, clay, and mud being used indifferently for the spawning beds. The depths at which they spawn range from eight feet to fifteen fathoms; the larger number probably spawning in depths of about eight or ten fathoms. In the Sault Ste. Marie River, and in the Detroit River, in the fall of the year, they congregate in great numbers, for the purpose of spawning. In a number of rivers emptying into Green Bay the White-fish was formerly taken in abundance in the spawning season. Saw-mills are numerous on all of these streams at the present day, and the great quantity of sawdust in the streams is offensive to the fish, and has caused them to abandon them. In one or two rivers of the north shore of Lake Michigan they are still found in the autumn.

"The Michipicoten River of Lake Superior, on the authority of Major Long, who commanded an expedition to this region in 1823, and George Barnston, esq., of Montreal, Canada, formerly of the Hudson Bay Company, is a favorite spawning ground of the White-fish. The Nepigon River, which our steamer entered while returning from the north shore of Lake Superior, about the middle of October, was said to contain schools of White-fish, which had probably entered the river for the purpose of spawning.

"There is a probability that there was a time when the White-fish ascended many of the clear rivers of the Northern Lakes, though that this was a universal habit is not probable, at any rate since the white man has been in the country.

"The fishermen, with their gill-nets, follow inshore the migration of the White-fish in the month of October, and a few days before the middle of November the spawn is ripe in a few fishes, and by the middle of the month is running freely, so that boats and nets are covered with the spawn and milt. Just at the time the ova are beginning to ripen, the Lake Trout, *Salmo namaycush*, has finished spawning, and is leaving for deep water. The White-fish continue to spawn until the last week of November or the first week of December, when they, too, leave the shore and seek deeper water.

"In the Detroit River, where there were fine opportunities for observing the fish at this period, owing to the advantages afforded by Mr. George Clark, of Ecorse, we found that the fish ascended the river about the last week of September, usually following the same course among the islands year after year. Mr. Clark's observations on the migration of the White-fishes had discovered that they ascended much farther years ago than they do now. They are still taken as high up as Cottrelville, twelve miles up the Saint Clair River. None have been caught above this point for many years. It is a singular fact that the White-fish are not known to descend from Lake Huron into the Saint Clair River. This is established by abundant evidence from continued fishing at Fort Gratiot, where Mr. Clark, between the years 1830 and 1842, took large quantities of the wall-eyed pike, *Stizostedion americana*, taking frequently one thousand barrels in a year. The catch of White-fish amounted to an occasional supply for his own table, except after long-continued storms from the northward, when the fish sometimes entered the river in schools. They were never found in this portion of the river in the spawning season.

"The same fact is claimed by the Indians in the Sault Ste. Marie River, that the White-fishes of the lake above never descend the rapids, while the White-fishes of the river, it is also asserted, never ascend to Lake Superior. There is not as good evidence for the truth in this locality as at Fort Gratiot; still, it may be the case.

"Examining the fish on the 30th of October, it was found that the spawn of the White-fish was hard and firm, with rarely a fish approaching ripeness. On the 1st of November, in the picketed pond, where the fishes are inclosed, numbers of fish were seen jumping from the water, principally the Herring, who take delight in this exercise at different seasons of the year. Occasionally a White-fish threw its bulkier form above the surface. On the 8th of the month Mr. Clark and I were out on the piling surrounding the pond, and found the White-fish jumping in numbers, so that there was a continual splashing of the water. They almost uniformly jumped in pairs, and we could see quantities of spawn in the water immediately afterwards, which rapidly sank. Mr. Clark and I both succeeded in capturing a pair in the act of leaving the water, and found male and female with milt and spawn running freely. Mr. Clark made use of a fine wire scoop as the pairs of fish disappeared from the surface, and almost invariably took a quantity of spawn from the water. The males were uniformly smaller than the females. I succeeded in catching a pair in which the female weighed seven pounds, and the male, who escaped before he was weighed, did not exceed one and a half pounds.

"November 9.—I again saw the White-fish jumping from the water in the evening, almost uniformly in pairs. Rarely there were three leaped together, one female and two males. In the pairs there was always a large one, evidently a gravid female, and a smaller one, the male. At this season of the year it is easy to detect the difference in sex, the abdomen of the female being swollen and rounded, while the males are leaner and angular in the abdominal lines. I saw by long watching that the males were worrying the females. They seemed possessed of strong sexual ardor, and followed the female with persistence, keeping close against her and with the head about even with the pectoral fin. Driven by the persistent attention of the male, the female arose vertically, he following, and she making a convulsive effort to escape, the water being from three to ten feet deep, they threw themselves together above the surface, and the spawn and milt were emitted at the time when, from their position, their vents were approximated. The spasmodic fluttering and effort observed suggested a sexual orgasm. At times I saw them moving rapidly beneath the water in the same close contact, and the male with his snout even with the pectoral fin of the female, often turning together with the white of the belly upward as she turned and twisted to escape him. Often as they came out of the water they would fall apart in different directions, but the male invariably turned immediately in pursuit, so that I was led to think they were monogamous, as is the fact with their relatives the Salmon and the Speckled Trout.

"November 10.—The White-fish jumping in great numbers toward sunset. In most instances, when near by, I observed a quantity of eggs, perhaps three hundred or five hundred, emitted at once. The milt of the male did not discolor the water. The same actions occurred as before observed, springing vertically from the water with a spasmodic, fluttering effort, the male's head opposite the pectoral fin of the female, turning together beneath the water until both abdomens showed upwards. Occasionally three sprang above the surface together. Sometimes the pair fluttered along the surface together for a long distance.

"November 14 and 15.—Went out to the pond at midnight, and again at 1 o'clock a. m., and found the White-fish jumping. The fact that they are quiet in the daytime, previous to four or five o'clock in the afternoon, indicates a parallel habit to that observed by Seth Green, of New York, in the shad, they, as he asserts, spawning principally in the night, though, unlike what was the case with the shad, we had no difficulty in finding spawners in the forenoon with the seine.

"November 18.—The fishing stopped all along the river. Visited the island. Cold, strong wind from the southwest. Thermometer 26°. No White-fish to be seen in the pond. A few Herring coursing around the piling.

"November 19.—Same as yesterday; no White-fish to be seen. Caught some of the herring with the dip-net; found their spawn still hard and small; their stomachs were full of White-fish spawn. Mr. Clark and I took a boat with two men and dredged in the river, obtaining a quantity of White-fish eggs. Nearly all were dead. Afterwards dipped a quantity from the pond, nearly all of which were dead.

"November 20.—Made another visit to the island. No White-fish seen in the pond. Cold, freezing weather.

"On the 24th and 25th of the month, while at Sandusky, Ohio, numbers of White-fish were found with the spawn in different stages of ripeness, though a majority of them had spawned.

"After spawning, the abdomen of the female fish is somewhat flabby and wrinkled, and the fish is undoubtedly relaxed and weak; but not to the extent that the Salmon, as well as certain other species of the *Coregoni*, are said to be reduced. The male shows but little indication of weakness.

"A series of ovaries were preserved from fishes of different sizes, and a count made by weighing the entire ovaries and then counting the eggs of a definite fraction, and calculating from it the number of the whole. Accurate scales were used for this work, and the table may be relied upon as correct:

Weight of fish.	Weight of ovaries.	Number of eggs.
	Ounces.	
2 pounds	5¾	21, 229
2¾ pounds	7½	28, 500
4 pounds	16	48, 000
7½ pounds	25	66, 606

"This makes an average of about ten thousand increase for every additional pound weight in the fish, which is precisely Mr. Seth Green's estimate, from his observations in spawning White-fish. Considerable variation in the weight of an equal number of eggs was observed, depending upon the stage of development at which they had arrived in the ovaries. During the spawning season, the fish from the river were found to have very little in their stomachs.

(*ii*) *Development of eggs and embryo.*—"It has been proven by repeated observations by fish-culturists that the higher the temperature of the water in which the eggs are placed the more rapidly the embryo fish develops within the egg, and the sooner it escapes from its inclosure in the shell. The temperature of the succeeding months after the spawning period probably regulates to a considerable extent the time of hatching of the White-fish in the Lakes.

"On the 11th day of April, at Ecorse, on the Detroit River, I visited Grassy Island in company with Mr. George Clark. The inside of the bag of a seine was lined with millinet and dragged in the river, bringing ashore a great quantity of mud and the small forms of life inhabiting the bottom. Sifting and washing out the mud resulted in finding one little worm-like fish-embryo, one-half inch in length, which I at once suspected to be the specimen sought after. Other attempts with the seine failed entirely of taking any more. Mr. Clark then proposed that we take a boat and search carefully on the surface for the young fish. Taking a pail and dipper, we shoved off our boat, and Mr. Clark pulling very slowly with the oars, I hung over the gunwale, and in a very few minutes found a little, active fish swimming with his head at the surface, and captured him with the dipper. He proved to be identical with the one taken with the seine. In the course of half an hour we captured forty, all of the same size and state of development. Most of them

were taken within five or six inches of the surface, though they were frequently seen coming up from as far below as they were visible. They were nearly white, with a pair of large, black eyes, were very active, moving continually, propelling themselves with a constant motion of the tail, and swimming with the head up and the body depending at an inclination of about 50°. They seemed apprehensive of danger, and turned quickly from the dipper when it came near them, occasionally escaping. They had no gregarious instinct whatever, and though occasionally taken in pairs it was probably an accidental circumstance.

"On April 14 we again visited the island and caught a number more of the young fish.

"A few days later Mr. Clark and I visited the breeding-house of Mr. N. W. Clark, of Clarkston. He had put down a large quantity of White-fish ova in November, and had taken the water flowing over the eggs from a pond that had remained frozen over nearly all the winter. The temperature of the water had remained at 34° or 35°, and the young fish had begun to hatch out on the 1st of April, and about the 9th or 10th were all out of the shell. This temperature is probably much the same as Detroit River at Ecorse, sixty-eight miles below Lake Huron, the current flowing at the rate of two miles per hour.

"The appearance of the umbilical sac in the specimens from both places made it evident that they were of about the same age, and indicated the fact that in waters that are frozen over throughout the winter the young White-fish escape from the egg about the first week of April.

"The temperature of Lake Michigan, Huron, or Superior probably does not descend below about 40° or 43° in ordinary winters, and the young fish would be likely to make their appearance a week or two earlier.

"The young fish lived in the glass jar of water two days, were then transferred to an eight-ounce bottle, and carried over thirty hours by rail and steamer, and did not arrive at their destination, Waukegan, Illinois, until thirty-six hours after they left Ecorse, Michigan. They were all in good condition, and were placed in a quart jar of fresh water. There were thirteen of them altogether.

"April 19.—The young White-fish are very vigorous, and are in continual motion. The water has been changed once. Although the yelk sac has not diminished, they act as if seeking food in their movements around the jar. They open their mouths very wide. Occasionally they take in dust masses and eject them again as if they were unpalatable.

"April 21.—Umbilical sac in one individual diminishing.

"April 22.—Umbilical sacs reducing rapidly.

"April 23.—Yelk sacs being rapidly absorbed. The membrane on the anterior part of dorsal line is also slightly diminished.

"April 24.—The umbilical sacs becoming minute. The fin-membrane anterior to position of dorsal becoming absorbed. At the center of the anterior ventral section of fin-membrane a slightly opaque white spot is apparent. In front of the anus, and on lower half of caudal, are similar ones. The color of the head is assuming a greenish tinge.

"April 25.—The globule in anterior part of yelk sac has become divided up into numerous smaller globules, scattered like beads, or more like a row of bubbles, through the length of the sac. When they open their mouths the gill-arches show quite distinctly. Excrement voided by some of them.

"April 28.—Umbilical sac entirely absorbed. First dorsal fin becoming well defined. Posterior section of dorsal membrane contracting. Furcation of caudal slightly indicated.

"After an absence from home of six days, I returned on May 6 to find only one alive. A

brown confervoid growth had developed in the water, and the young fish attempting to swallow it always got it entangled in its gills and soon died.

"In my absence I visited Clarkston and purchased for private parties from Mr. N. W. Clark one thousand young Trout, which I brought safely to a brook two miles north of Waukegan, Illinois. Mr. Clark gave me one hundred and fifty young White-fish, most of them with the yelk sac only partially absorbed. The difference in temperature evidently made some difference in the rapidity with which the umbilical sac disappeared, as the young fish I had carried home were in the same stage of development, April 14, as when I had visited Clarkston previously. Now, May 1, the fish in Mr. Clark's troughs still retained considerable of the sac, while on the 28th of April the young fish in the jar had lost it entirely. The jar had been kept in a moderately warm room, with a temperature of about 65°, while the water in the troughs at Clarkston flowed from a pond that had been covered with ice until within a few days previous.

(iii) Rate of Growth.—"Further research for the young fish was unavoidably delayed until the 1st of July. Towards the end of June, from a seine-haul at Waukegan, a specimen of *Coregonus albus*, measuring eight and three-tenths inches in length, one of *C. quadrilateralis*, measuring seven and four-tenths, and one of *Coregonus harengus*, measuring three and four-tenths inches, were obtained.

"At Sault Ste. Marie, Michigan, on July 2, with an Indian in a birch canoe, the vicinity both above and below the rapids was explored in the current and in the still water and along the shores, to find the smallest grade of White-fishes that were to be had. Along the shore, in the sharp current, schools were found of which the smallest taken measured four inches and nine-tenths, and the largest six inches and one-tenth. It was quite evident that they had all been hatched the same season. Another excursion in the birch resulted in nothing materially different. The minimum measurement of the next grade taken was eight inches and three-tenths.

"At Shoal Island, one of the Apostle Islands of Lake Superior, a White-fish was taken from the pound-net about the middle of August measuring six inches in length, and another measuring six and one-half inches.

"On the 3d of December, at Point Edward, Canada, at the outlet of Lake Huron, two specimens of *Coregonus albus* were obtained from a seine, one measuring six inches and eight-tenths, and the other seven inches and seven-tenths.

"It is very probable that the Shoal Island fishes of August and the Point Edward ones of December 3 were the larger-grown individuals of the same generation as those taken at Sault Ste. Marie in July. The difficult point to decide was in what year the beginning of this generation should be placed.

"The only positive data with reference to the growth of White-fish are found in the observations of Mr. Samuel Wilmot, of Newcastle, Ontario, in charge of the government hatching house of Canada. Mr. Wilmot reports that in November, 1868, he placed a quantity of spawn in the hatching troughs for an experiment, and in the following March and April a large number of young fry made their appearance. He failed in finding food adapted to the young fish, but a number that escaped through the screens were carried down to a small pond, where they seemed to thrive and soon became well-developed young fish. In the month of September they were exhibited at a fair in London, Canada. They were then about five inches long. In December the young fish had attained the length of seven inches.

"Mr. N. W. Clark, of Clarkston, Michigan, visited Wilmot's hatching-house in 1871, and in an address before the house of representatives of Michigan said: 'Enough is known, from the success of Samuel Wilmot, esq., of Canada, to sustain us in the assertion that they (the White-fish) in-

crease in weight about three-quarters of a pound a year, as those he had when we saw them, last January, we judged to have weighed about one and a quarter pounds, being then about eighteen months old.' These are the only records of observations of the growth of the White-fish, and evidences of this character are the only ones of any value of the rate of growth.

"An attempt was made several times from large lifts of fish lying in the fish shanties to arrange the different sizes of White-fish in series, with the hope that some evidence of the rate of growth per year would result. It was always found that the row of fishes, from the larger to the smaller, assumed the form of a spire-like pyramid, and a 'straight-edge' laid at their heads would have touched the noses of every one in the series, and on the opposite end it would have touched every tail, so perfectly regular was the gradation. It was difficult to believe that the White-fishes, of from nearly five inches to six or seven, had attained these dimensions in three months from the little half-inch embryos of April and May, though none of less size were found with the most diligent search.

"Mr. Wilmot's young fish measured about five inches in September when four months old. Experience has proved that there is a more rapid growth of the young Trout and Salmon afterward than during the first two months. The observation on the development of the young White-fish from April to the first week of May showed the slightest perceptible difference of length and bulk. If we assume them to be the fish of this season, then they had increased ten times in length in two months, precluding the possibility of a more rapid growth afterward.

"It is altogether probable that the fish measuring from four to seven inches in July were those of the previous season's hatching, and about sixteen months old. It is equally probable that the Point Edward fish of seven inches are those of the same season, as the five months intervening the 1st of July and the 3d of December should have produced considerable growth. To confirm this opinion we have Mr. Wilmot's statement that his White-fish had attained the length of seven inches in December. These evidences of the rate of growth are the only conclusions we have been enabled to adopt with reference to the size attained at different ages. Nor does this decide the average size of the growth of the White-fishes the first and second seasons."

The act of spawning, with the accompanying movements, is thus detailed by Mr. Peter Kiel, of Wolfe Bay:

"From thirty years' experience as a fisherman, and after obtaining all the information possible from others on the habits of White-fish, I beg leave to remark that during the month of November the White-fish are known to unite, or join in pairs, male and female, and that they approach the shore for the purpose of spawning. Should the weather be very cold they move more rapidly and arrive at their destination about the 15th. Their favorite place is a sheltered or land-locked bay or inlet having a sandy or gravelly bottom. When in from ten to twenty feet of water the female, endowed with an instinctive knowledge that her time has come for depositing a part of her spawn, selects a spot and commences to dig vigorously with her head, at the same time moving the tail rapidly to stir the sand or gravel; in a short time she forms a nest about two inches deep; the male, staying close by, seems to be attentively watching her movements. When the nest is satisfactorily arranged she ejects a quantity of spawn into it. The male immediately darts alongside of her and impregnates it with the milt. He then moves off a little way while she covers it partly over with her nose and tail. They remain near the spot two or three days, until all the eggs are deposited in the same nest, when they return to the deep in search of food, leaving the eggs and young fish, when hatched out, to shift for themselves. In the mean time the spawn, being heavier than water, remains on the bottom, which it would do even if not partly covered

over, nature having provided an adhesive substance which fastens it to the sand or gravel. It remains about one hundred days, when the young fish emerge into life. While they were exposed for so long a time, we cannot fail to admire the beautiful and mysterious laws of nature manifested in their protection from the severity of the weather, from predaceous wild fowl, from voracious fish, and from reptiles, which during the winter are in a semi-dormant state. As soon as the young fish are strong enough to move off they gradually work out into the deep, where they remain three or four years, when they attain their full or average size, and move round periodically with the parent fish to their various feeding and spawning grounds.

"White-fish are very prolific, and would multiply very rapidly if not destroyed by a reckless mode of fishing. Many valuable fishing grounds have been rendered useless by hauling seines during the breeding season, since, in such case, the parent fish are not only destroyed, but the spawn is disturbed by the seines dragging along the bottom so that it will not hatch. Another destructive mode of fishing is to set gill-nets across the mouths of bays or inlets, where the fish, in accordance with their habit, enter in periodically; these nets turn their course some other way, and it will be clearly understood that they are so social in their nature that in whatever direction the main body of them incline the others are sure to follow. Our fishery laws have done much, already, toward the prevention of such abuses."

Mr. John W. Kerr, overseer of the Hamilton district, Ontario, Canada, wrote the following paragraph in a letter to Professor Baird, on the spawning of the White-fish in Lakes Erie and Ontario:

"The White-fish spawn, both in Lakes Erie and Ontario, on the reefs and rocks, during the month of November. The eggs dropping into the crevices of the rocks are protected from suckers, a fish always on the alert at this season of the year to devour the eggs. The two specimens sent herewith you will please find by examination differ from each other in many respects. This you will be able to find out to be the case only by close study and observation. The Lake Ontario fish you will find to be a finer and superior fish than the Lake Erie White-fish, both in delicious delicacy of flavor and taste, and the whiteness and richness of the flesh. Still, as regards the food for this fish, in both lakes, I have in every instance and on all occasions found it the same. The fish live by suction.

"There is an observable difference in the shape of the White-fish of Lake Ontario as compared with the shape of the White-fish of Lake Erie. Thus you will please find that the Lake Ontario White-fish are rounder and broader on the back, while the Lake Erie White-fish are flatter and sharper on the back."

ARTIFICIAL PROPAGATION.—At so early a date as November, 1857, according to Mr. Milner, the first attempt placed on record was made by Mr. Carl Muller, of New York, and Mr. Henry Brown, of New Haven, to propagate the White-fish artificially. The lake which it was proposed should be first stocked was Lake Saltonstall, near the city of New Haven. Eggs were procured and impregnated artificially. The knowledge of the art was, however, crude, pisciculture being in its infancy, and the experiment was but partially successful. The eggs were packed in moist sand and placed in the bed of the stream on their arrival, the White-fish eggs on a sandy shoal of less than three feet in depth. The presence of young fish in great numbers in the following March and April was believed to result from the eggs, although the exceedingly common error on the Great Lakes of mistaking the schools of small cyprinoids for young White-fish (which they very much resemble except in the absence of the adipose dorsal), may have been repeated here. In the fall of 1858 the experiment was renewed. There has been no reference made to any permanent results from this experiment in the reports of the State commissioners.

"A more successful series of tests were begun in 1868 by Seth Green and Samuel Wilmot in applying artificial culture to this species, and in the succeeding year by Mr. N. W. Clark, of Clarkston, Michigan. They were found to be very delicate and difficult to hatch in the first few years of experimenting, but methods were perfected that made their production as certain and with losses nearly as small as in other species. The necessity of production of immense numbers in attempting to multiply the market species of fishes established the fact that the apparatus used in trout-hatching had to be extended over a wide area to accommodate them. The culture of the White-fish and the Salmon Trout induced modifications of apparatus at the New York State hatching establishment."[1]

On page 548 of the same report Mr. Milner continues his observations:

"A few extracts from a letter of Mr. Clark, to the board of fish commissioners of the State of Michigan, will advance his arguments in favor of brook or surface waters in preference to spring water. Mr. Clark began his experiments with White-fish in 1869, hatching a small percentage of the eggs he procured:

"'In November, 1870, I started again for Ecorse for the purpose of procuring more spawn. Mr. George Clark, at his fishery, very kindly rendered me all the aid in his power, furnishing the parent fish for the purpose of trying further experiments in this new enterprise. I succeeded in obtaining all the spawn needed for further trial, but he was so anxious to make it a success that he sent his man to me with an extra lot which he thought might be in better condition. I succeeded in hatching a much larger proportion of them than the year before, but raising them with artificial food was attended with no better success. This second effort and failure led me to investigate the cause, and after much thought I came to the conclusion that, if we ever succeeded in making this branch of pisciculture a success, we must study the principles of nature more than had ever been done before. I became fully satisfied that by arranging so as to use water taken from a pond or lake entirely frozen over, it would retard the development of the eggs to the time required by nature, which proved by subsequent experience to be about April 1. I then consulted Messrs. George Clark and John P. Clark, and made known to them my convictions, and so strongly were they convinced that I had struck the key-note to insure ultimate success that they proposed to furnish all the necessary materials and a portion of the labor to enable me to go on and erect a large hatching establishment. This was located about eighty rods below the spring where we had been experimenting the two years previous with the unsatisfactory results above stated. This location was supposed to be a sufficient distance below the main spring, so that by damming the water and raising a pond it would freeze over and remain so during the period of incubation. Our views proved to be correct, as the 500,000 of eggs which we placed in the hatching boxes November 15 of that year were preserved in fair condition, and with one-quarter less labor in caring for them than formerly. They did not commence to hatch until April 1, and it was estimated that we succeeded in hatching at least fifty per cent. of the eggs we had taken four and one-half months previously at the fishery of George Clark. Of these young fry, some 100,000 of them were put in Detroit River, at or near his fishery place, and no doubt at this time they are thriving finely in the waters of Lake Erie, which abounds with abundant natural food for them, and in a year or two more they will doubtless return to the same place where they were deposited. The balance of them we placed in three small lakes in Oakland County, some of which have been seen within the last few months, doing finely.

"'This experiment proved so great a success that again, the next November, 1872, through

[1] Milner in Report of Commissioner of Fish and Fisheries, Part II, p. 545.

the encouragement of the Messrs. Clark and the United States Fish Commissioner, I doubled the capacity of this hatching house and procured 1,000,000 of the ova from the same grounds, and proceeded as before with some improvements I made in the *modus operandi* of hatching, about February 20. Mr. Milner, deputy United States commissioner, arrived at this place for the purpose of aiding me in packing and shipping a lot of the ova, which were then in an advanced stage of incubation. We estimated from actual count that sixty-six per cent. were in such an advanced state that they were secure from any further mortality. We then shipped to San Francisco 216,000 in the most perfect condition. About March 10 I received an order from the Commissioner at Washington to send the same number again to the same place, which I should have done, but from the fact that the eggs had become so far advanced that I felt quite confident they could not be transported so great a distance successfully, and only sent 116,000, which I am most happy to have heard arrived in excellent condition. Soon after this the weather became much warmer and the ice all thawed from the pond, and by the 20th of the month the eggs then remaining in the troughs commenced hatching. The water had then risen to a temperature of 45°, which sudden change caused the eggs to turn white, and soon all were worthless. Quite a large number had already hatched out, and I removed part of them to the same lake where Mr. George Clark and myself had put in a large number the year before, and placed about 25,000 in a small lake at Clarkston Village.

"'This sudden change in the condition of these eggs I cannot account for, only from the fact of the change in the temperature of the water at this late stage of their development. I am fully satisfied that if the ice had remained in the pond as late as the previous year I should not have lost two per cent. from the time I made the last San Francisco shipment. This experience satisfied me that spring water, although it may not be used until it advances a long way down from its source, is not the place to hatch White-fish. Although this pond was clear from ice March 15, the ice remained in our lakes in this region until May 1.

"'This species of eggs, and especially those not good and not perfectly impregnated, placed in spring water at a temperature of 46° (which is about the same as all good springs) in winter, will start out a growth of vegetable fungi more than four times faster than if placed in water at 33°, which is the temperature of ice-water, and it is next to impossible to employ help enough to pick out the dead eggs (when in spring water) when you have over a million, as I had the last two seasons. Even in ice-water last winter, which preserved the eggs much longer than in spring water, it required from eight to ten persons to keep them in fair condition, and then sometimes they were necessarily left too long in an unfavorable condition.

"'These facts are conclusive proof to my mind that the ova of White-fish should be kept entirely away from the influence of spring water, or any water which will be liable to change during incubation, and all houses where White-fish are to be hatched should be constructed upon some lake or pond that freezes over early and does not thaw out until April 1. It is stated as a reason why spring water is better for hatching fish eggs than lake water, that it is generally more free from sediment, some kinds of which are highly detrimental to the successful hatching of the fish ova. Whereas our inland lakes freeze over early in the fall, and are not free from ice until late in the spring, this ice is perfect protection against any agitation of the water, and gives an opportunity for any sediment that may be in it to settle to the bottom, where it must remain until spring, and until the eggs are hatched and distributed. Consequently the water in all of our inland lakes is, during winter, as clear as crystal.

"'You also wish me to give my views in reference to using Detroit River water. To this I will

frankly say that I should much prefer it to any spring water in this or any other State for hatching White-fish. But there are some objections which arise in my mind even to this water. I am aware that this species of fish are natives of our great lakes and rivers, and consequently it would be supposed that this water must agree with them, and that success would be certain if this water was used. But has it not occurred to all persons who have given this subject much thought that much the largest proportion of these fish run to the shoals of those lakes during spawning season to deposit their ova? These shoals are the first to freeze over in the fall and the last to thaw in the spring. This keeps at nearly the same temperature during incubation. Although it may be said that during their migration from Lake Erie to Lake Saint Clair some deposit their spawn in the rivers, it is not very probable that much of it is hatched. I am aware that many hatch in and about the ponds where the fishermen preserve their fish for winter use. This tends to prove that the shoals are the place where they hatch most largely, as the ice remains in these ponds much longer in the spring than in the strong current in Detroit River. If water is used from this river it must change in temperature many times during the winter, as it is well known that the ice leaves the river quite often during the four and a half months of the period of incubation. No one can gainsay the fact that in the hatching of fish ova, if the water is of a perfectly even temperature, it will be attended with more favorable results than when frequently changing, from any cause, even if such change is not more than two or three degrees. Is it not also a fact that the ice frequently leaves the lower part of Lake Saint Clair early in March? If so, would not the westerly winds roll the water in the upper part of the river? This sediment would be deposited on the eggs, and, in consequence of its fine, clammy nature, would be injurious to them. I noticed this was the case in a little experimental arrangement of A. M. Campau, some two years since, where this water was used. I examined these eggs several times during this process, and found a fine clammy substance accumulating on them. They were gradually dying, and I do not think any were hatched. These eggs were taken from our hatching boxes, and were in perfect condition, as they were so far advanced in development that the embryo fish could be plainly seen with the naked eye. For these reasons I am forced to the conclusion that there is more suitable water for hatching this species of fish eggs than the Detroit River.

"In conclusion, the advantages afforded American fish-culture from the cultivation of the White-fish, as they have just been enumerated: These are, (1) more careful and perfect methods, resulting from the experience in the culture of the most delicate and difficult species whose propagation has been attempted by culturists; (2) the perfection of three forms of apparatus for hatching fish eggs, embodying the important improvements of facility in handling the eggs and removing sediment and confervæ, and greatly economizing space; (3) the contrivance of a superior case for the carriage of eggs; and, besides, a possibly successful, entirely new method in the hatching of eggs and the discussion of and practical tests of conditions of water suitable to the eggs of a species that we are not (at any rate thus far) able to supply with food."

"These experiments," wrote Mr. Milner, referring to those made by Mr. N. W. Clark, "were all attended with considerable success, though the large percentage of loss, compared with that in trout and salmon hatching, was anything but encouraging. The screens in the troughs, in most instances, were the same as those used for the Trout, and the embryo White-fishes, being smaller, escaped and ran over into the waste troughs and down into the ponds below. This was in some measure a fortunate circumstance, at Mr. Wilmot's establishment, for the young fish, finding their natural food in the ponds, grew and thrived, and afforded the only positive data there are of their rate of growth. In the succeeding year (1870) Mr. Green and Mr.

Clark made additional experiments, and from the experience of the preceding year, having learned the necessity of immediate attention to the White-fish eggs after they were placed in the troughs, began the work of removing the unimpregnated eggs within two or three days' time, and, giving them close attention, during the season hatched out a much larger percentage of eggs. Mr. Green, in 1869, distributed a quantity of the White-fish spawn to numerous applicants who responded to an advertisement offering it for distribution. Some packages of spawn from this supply were sent by steamer to Mr. Frank Buckland, inspector of salmon fisheries for Great Britain. In referring to the condition of the eggs on their arrival in London, he says, 'A good proportion of the White-fish eggs were alive and well.'

"Some temporary troughs were put up in Detroit, Michigan, and supplied with the ova, under the direction of Mr. A. M. Compeau, Mr. J. P. Clark, Mr. George Clark, and Mr. James Craig.

"Experiments were again made by Mr. Green, Mr. Clark, and Mr. Wilmot, in 1870. More than a million of ova were supplied by the liberality of Mr. J. P. Clark and George Clark, without expense, from their ponds in Detroit River. Mr. Green also made experiments in the breeding of Salmon Trout and Lake Herring, with some success.

"In 1871 these gentlemen just referred to, from Detroit and vicinity, failing to arouse the interest of the State authorities in the matter of fish propagation to the extent they desired, furnished Mr. N. W. Clark, of Clarkston, with the necessary funds for the erection of a building, sixty-four feet in length by twenty in width, in which were put up twenty-six troughs, sixteen feet long and one foot wide. The entire building was devoted to the hatching of White-fish, and the number of eggs laid down estimated at about one million. The experience of the previous years aided Mr. N. W. Clark to a most complete success, and by the 1st of April the fish began hatching, and before the 13th of the month the troughs were swarming with young White-fishes. Between the 20th and the 30th of April these were all distributed by Mr. Clark in a number of inland lakes in Oakland County, Michigan, and into the Detroit River. Mr. Wilmot again procured about one-half million of White-fish eggs, which were handled with improved success.

"Mr. Green gave less space to white-fish eggs this season, and laid down large quantities of salmon-trout ova, with the purpose of distributing the Trout in the inland waters of the State.

"In 1872 an employé of Mr. Green devised a new apparatus for hatching fish, that economized space to a great extent and afforded him room for a large supply of both salmon-trout and white-fish ova. Visiting his establishment in January last, we found them hatched out in large quantities, and orders arriving daily for the fry, to stock the waters of inland lakes in all parts of the State. Mr. Wilmot obtained a supply of white-fish spawn at Sandwich, on the Canadian side of the Detroit River."

The employé of Mr. Green above referred to was a Mr. M. C. Holton, whose invention is thus more fully described:

"Instead of placing a single layer of eggs in a long, narrow trough, he has prepared a can or box, of perhaps a foot square and several feet in height. This is filled with shallow trays of about half an inch in depth, with wire-gauze bottoms, on which the eggs are placed, so that with twelve trays, having a surface of one square foot each, he accommodates twelve times as many eggs as by the ordinary method. The box is so arranged that a current of water is carried by a covered pipe down the side of the can to the bottom and allowed to enter at that point. The current in its overflow passes from the bottom to the top, and the water circulates freely over the eggs. This arrangement has the additional advantage that once a day, or oftener if necessary, the trays can be taken out singly, and any diseased or defective eggs removed, thus improving the entire mass."

In 1873, a device to accomplish like results was made by Mr. N. W. Clark, of Clarkston, Michigan, and patented in 1874.[1]

This arrangement employed the troughs, but divided them into compartments by means of water-tight partitions or bulkheads; into each compartment a box containing a series of trays filled with eggs is placed and covered with a pan of perforated tin, upon which the water falls and descends through the perforations upon the screens and eggs beneath, passing through all and escaping at the bottom, afterward flowing over the partition upon the cover of the next box, and so throughout the series of compartments until it escapes through the waste-way at the end of the trough. By this arrangement a very small quantity of water is required for a very large number of eggs, and all the advantages of handling and removal of sediment and considerable economy of space are afforded.

Another combination of the trough and tray methods is in use in California, devised by Mr. John Williamson, of the California Acclimatizing Society. This is very similar to the one just described, except that the flow of water through the screens and eggs is from below instead of from the top. This model was not the result of work in white-fish hatching, as in the case with the two first named.

An experiment was made by Mr. N. W. Clark in the hatching of white-fish eggs, which were laid in single layers of woolen cloth stretched on very thin frames of wood, packed in a box imbedded in sphagnum moss within a refrigerator, and the whole kept at a temperature a little above the freezing point by ice. The eggs are left entirely undisturbed after they are first arranged, and the only care on the part of the attendant is to keep the temperature above the freezing point. The presence of dead eggs does not seem to contaminate the living ones in this condition, and very little confervoid growth appears. A quantity of eggs carried forward in this manner through the winter appeared to be in excellent condition, development progressing slowly, and a few, taken from the cloths and placed in spring water, hatched out within a short time as well-developed embryos. If this method, after full and thorough trial, should prove successful, it would make the work of hatching a matter of neither effort, care, nor expense. It has been a matter of too short experience and of experiment on too small a scale to warrant its positive success.

An improved case for the carriage of eggs long distances by railroad is another device perfected by Mr. N. W. Clark in 1872. It is a modification of the ordinary case containing circular cups, the cups being square, and in this form economizing space very much. The cups of tinned iron, about four inches square and two inches high, rest in trays, with low partitions forming low compartments that retain the bottom of each cup and hold it solidly in place. The trays are set within a square tin box, in which they fit with moderate tightness, and are placed, when containing the cups, eight or ten in the box, one above the other; this box is set within another box of tin large enough to leave an open space on all sides, to be filled with sawdust; a tube is inserted through the bottom of the inner box, piercing the bottom of the outer one, so as to permit communication with the air on the outside. The whole is then placed for protection within a strong wooden box, in the bottom of which is a frame resting upon stiff springs which relieve the eggs from heavy jarring; rubber or cloth bumpers on the sides of the box prevent lateral swaying and jolting. A cover is fitted to the inner box, which may then be covered with sawdust to the level of the higher outer one, when the cover of this is to be shut down. The outside wooden box is

[1] Report U. S. Fish Commission, part vi, p. 546.

fitted with handles and with a tight lid on hinges, which may be locked. Small auger-holes are bored through the outer or packing box, and air may be admitted to the whole interior of the egg case through the tube referred to in the bottom, the cups being pierced with small holes, so that when in place they are directly over circular openings in the trays, and a communication of air is established throughout. The eggs may be packed in moss, in the ordinary manner, in the cups which experience seems to prove to be the best manner for long journeys.

The method of Mr. Atkins in shipping salmon-eggs packed in moss, but with pieces of mosquito-netting laid above and below the eggs, is a great convenience in unpacking them, and could just as well be applied in the cups. This, though less simple than the ordinary egg-carrier, is sufficiently simple for practical purposes, and possesses most important advantages for carrying eggs long distances and over rough roads, the small area of surface within the boxes preventing any tendency of the eggs to slide together at one side. The square boxes resting in trays are put together in much more compact form than the cylindrical boxes embedded in moss, and the springs beneath the boxes of eggs are of course an important addition. Mr. Clark believes the hatching apparatus in the refrigerator to be as well adapted for the carriage of eggs as for hatching them.

The use of surface or brook water in any permanent establishment seems to have been first employed by Mr. Samuel Wilmot, of Newcastle, Canada, the greater number of hatching establishments using spring water.

In the hatching of White-fish, Mr. Clark has contended for the use of brook water in preference, because of its lower and evener temperature throughout the winter, and the consequent retardation of the hatching of the fish which he has contended is an essential provision in nature to their welfare, and that hatching them two months or more previous to the natural time under artificial conditions is a mistaken method that will not result in the maturing of any considerable numbers in the cold waters in which they are released. Although this view has not been established by practical observation, yet it raises a question of considerable importance, and one which merits a full discussion, in view of its bearing on the practical work of fish culture.

Mr. Milner's account of the further progress made in this branch of fish culture is resumed in another place, as follows:

"November 11, 1872, I met Mr. N. W. Clark at Ecorse, and in company with Mr. George Clark we visited Grassy Island for the purpose of obtaining white-fish spawn. The box which Mr. N. W. Clark has devised for carrying ova is constructed so as to carry a greater quantity of eggs, with easier carriage, than any in present use. It is a large square can, of zinc, about thirteen inches square and twenty-two inches deep. This, for protection, is set inside of a strong wooden box, with a light frame in the bottom, supported on stiff springs. Strong handles are fastened to the box, for convenience in handling, and to prevent any necessity for throwing it out of level while carrying it. The zinc can contains ten trays, each of which carries fifty-four small boxes, two inches square and two inches deep, set in compartments, each compartment having an inch hole cut in the center. The partitions between the compartments are just high enough (about five-eighths of an inch) to inclose the bottom of a box and hold it firmly in its place. No covers are provided for the boxes, but a large cover can be fitted to the zinc can, and a lid, with a good lock, is fitted to the outside box. The bottoms of all the little boxes are perforated, the position of the holes being directly over the circular hole in the compartment of the tray. The zinc can has also holes in the bottom, and the wooden box has three-quarter inch holes bored on each side, near the bottom, so that there is drainage for the surplus water of all the boxes, and a free circulation of air throughout, which is deemed important by some of the fish-culturists.

"At the island the most perfect arrangements were provided by Mr. George Clark for obtain-

ing the spawn. Two tanks of about five feet diameter were placed at the edge of the shore and partly filled with water. As soon as the bag of the seine was on the beach the men picked up the White-fish and put them immediately into the tanks. The pans for impregnation were close at hand, and as one man lifted the fish above the water in a dip-net, another took it from the net, and with his right hand over the head of the fish and his left around the tail he held it over the pan, standing at the left of the operator. The left hand of the operator was put against the back of the fish and the right hand used in manipulating the abdomen. It was found that to induce the eggs to flow freely from a fully ripe female, all that was necessary was to apply a gentle pressure just behind the pectoral fins, just where the nudging and bunting of the head of the male fish is applied while racing her through the water. Not until the greater part of the free eggs had fallen into the pan was it necessary to slide the hand along the abdomen. The free eggs came away in a steady, liquid stream, but from a fish partially ripe their extrusion was slow, and in masses comparatively dry that did not freely disengage themselves from the fish and fall into the pan.

"The female exhibited the most indications of pain when the pressure was applied in the vicinity of the ovipore. The milt from the male will flow in from one to three jets by pressure in the vicinity of the anus.

"The method employed by Mr. N. W. Clark was that which was original with Mr. Seth Green, using the smallest quantity of water possible. The eggs, after falling into the pan, and the milt, having been stirred up with the water, were allowed to stand about half an hour, when the milt, and water were poured off and the eggs carefully rinsed through several changes of water. A small quantity of water was left with the eggs when they were perfectly clean. By repeated actual counts, and by arranging on a plate in a true square, it was found that a large tablespoon, moderately heaped up, contained about a thousand eggs. Eight ripe white-fish eggs will lie entirely within the space of an inch, and the ninth will lie partially across the line.

"A pat of moss was then put into the cups, and a piece of canton flannel, cut into the form of the Swiss cross, after thorough saturation with water, was pressed lightly down into the cup, and a tablespoonful of eggs poured upon it. The canton flannel was used to line the sides of the boxes, because it was found that the contact of the zinc was fatal to the eggs, probably from the poisonous elements of the oxide. The patch of canton flannel proved to be a great convenience in taking out the eggs, as all that was necessary was to take the edges lightly in the fingers and remove it from the box, and dipping the cloth with the eggs into a pan of water, they were rinsed off with a few quick motions, without any tedious picking and rinsing the eggs free from particles of moss. In arranging the eggs for transportation for a short distance, the use of the cloth patches is undoubtedly a good method. After filling the boxes they were placed in the trays, and the trays adjusted within the zinc can, when water was poured on until the whole contents were thoroughly saturated, when the lid was closed and locked and the case was ready for transportation to the hatching house. A small fee to the baggage-master excites considerable interest in the safe-handling of the box.

"Two trips were made from Ecorse to the hatching house at Clarkston, and about 1,330,000 eggs were put into the troughs, Mr. Clark having increased the number of troughs to fifty for the purpose of receiving the extra supply of eggs. One half of the eggs were the property of the commission, the other half to be controlled by Mr. J. P. Clark, of Detroit, Mr. George Clark, of Ecorse, and Mr. N. W. Clark, of Clarkston. The eggs received attention from the second day after they were placed in the troughs until about the middle of January, the eyes of the embryo then showing distinctly, and the subsequent loss being very small.

"Upon receipt of the instructions to ship a quantity of eggs to the State commissioners of California, a case similar to Mr. Clark's was made, substituting a good quality of tin for the zinc, and adding a second square can, large enough to contain the can with the trays and cups, and leave the space of an inch on all sides.

"Arriving at Clarkston on the 18th of January, the weather was considered too severe to hazard the shipment of the eggs at the time, and it was delayed until the 20th. The thick covering of frozen snow and ice prevented the possibility of obtaining moss, and a good quality of sponge was substituted. This was prepared first by whipping out the calcareous dust that it contained, and, after being cut in thin slices, was thoroughly washed through several changes of warm water. Pieces were then fitted to the bottom of the cups, and while standing in a pan of water a half tablespoonful of eggs was poured in, a thin slice of sponge, fitting the inside of the cup, laid lightly over the eggs, and the remainder of the spoonful poured in, when a third piece of sponge was put over them to cover them. The tray, with the cups, was then put into the inner can, which was placed within the second can, with one inch of sawdust filling the vacant space on the sides, bottom, and top. A piece of burlaps was tied over the top, and the whole placed upon the springs, within the packing-box, and the lid fastened down. The packing-box had two half-inch holes bored near the bottom to admit the air. The filling of sawdust was considered as a necessary safeguard against the cold weather of the time.

"The case was put in charge of the baggage-master, and I accompanied it as far as Omaha, Nebraska, attending to its transfer from one train to another, and regulating its position in the car. At Omaha it was given in charge of the express company, and the messenger instructed as to the effect of heat and cold upon the eggs, and a letter containing full instructions sent with the box to be delivered to the messenger at Ogden, where the box was transferred to his care, there being no further change of messenger between that and San Francisco, California. On two sides of the box, in distinct letters, was printed the caution, 'Fish-eggs; must not be jolted or allowed to freeze.'

"The weather continued cold throughout the time the eggs were on the way, and they arrived at their destination in very bad condition. Mr. Stone attributed the damage to the use of sponge, and the sawdust packing preventing ventilation. Mr. Rudolph Hessel, an experienced fish-culturist of Offenburg, Germany, while visiting Washington, informed me that he had used sponge for packing eggs for long distances with entire success. The lack of ventilation is a more probable cause, though the description given by Mr. Buckland of the method of packing the eggs received from Seth Green's establishment in January, 1870, was similar in the fact that the cups containing the moss and eggs were buried in the sawdust. A small quantity, received from Mr. N. W. Clark at the Smithsonian Institution this winter, was packed in the same manner, using sponge and burying the cups in a pail of sawdust, and they were found to be all alive after a fifty hours' journey.

"The necessity of a certain supply of oxygen to the eggs has been very thoroughly proven by the researches of W. H. Ransom, M. D., of Nottingham, England, published in the first volume of the 'Journal of Anatomy and Physiology.' The experiments were made while investigating the nature of the rhythmic contractions of the yelk, known to occur in the living eggs of fishes. Among several experiments, in which by ingenious methods the oxygen of the atmosphere was kept from contact with the eggs, those of the stickleback being employed, he relates as follows:

"'I therefore made a series of suffocative experiments on impregnated and unimpregnated eggs, using aërated distilled water in cells, all of the capacity of .05 cubic inch, sealing the covers with hot wax, and varying the number of eggs in each cell. Five observations were made with

unimpregnated eggs, having, respectively, thirty-five, thirty, eighteen, nine, and seven eggs in a cell; and although, in consequence of the accidental loosening of the wax, and the entrance of a little bubble of air, the duration of the contractions was not in all cases inversely as the number of ova in the cells, yet the general result was rhythmic contraction, and the pseudo cleavage continued longer in the cells containing the smaller number of ova, the eggs which lay nearest to the air-bubble always being the last to cease to move; the accidental failure of the luting affording thus additional evidence of the importance of oxygen. In all the cells the contraction ceased in from twenty-three to thirty hours, or one-fourth of the time they continued in aërated water and unlimited space. Five similar observations were made on impregnated eggs, with forty-eight, thirty-eight, seventeen, ten, and seven eggs in each cell, with similar but more marked results; the yelk contractions ceasing earlier than in the unimpregnated ova. The cleavage was more rapidly checked than the pseudo cleavage, and still more so than the yelk contractions. Seven experiments were then made to ascertain the relative dependence upon the presence of oxygen of the movements which result in cell multiplication and differentiation, and of the muscular contractions of the embryo compared with the yelk contractions. Two healthy developing ova were sealed in similar cells at seventy-six, one hundred and one, one hundred and twenty-seven, one hundred and fifty, and one hundred and seventy-four hours each, after impregnation, and two free embryos at twenty-four and forty-eight hours after hatching. Although the proportion of active organic matter to the medium was so very much less than in the previous experiments with recently impregnated eggs, yet the process of development ceased in all in about seven hours, and the yelk contractions did not continue more than eighteen hours. The movements of the heart continued about the same time, those of the trunk ceasing before the heart. The embryos in the later stages of development more quickly ceased to move than those in the earlier. The inference is, I think, not to be resisted, that oxygen in the surrounding medium is an essential condition of the exercise of the property of rhythmic contractility possessed by the food yelk, as well as of the fissile contractility of the formative yelk.'

"Though Dr. Ransom admits that the quantity of oxygen consumed in these movements appears to be very minute, yet it indicates that a large quantity of eggs, confined, in a small, air-tight space, would consume the oxygen to an injurious extent, during a long journey, and sufficient ventilation is to be considered as one of the necessities in packing eggs for transportation. The sawdust that filled the space around the inner can, in the California shipment, was crowded down with a piece of board, and may have, in consequence, rendered the package more completely air-tight than in the shipments referred to similarly packed. A later shipment arrived in most excellent condition. The cups in the cases were made four by four inches square, by two deep, with no packing between the cans, and the eggs packed in moss. The most ample ventilation was provided for in the egg-cases. The oxygen given off by live moss is probably the principal reason for its special adaptation in packing eggs for shipment.

"Dr. Ransom's experiments on the effect of heat have also a practical value in the treatment of fish ova, both in transportation and in the troughs. He says: 'Some eggs on the stage of active contraction were cooled until the thermometer placed on the cell stood at 32° F. They all became still, and their yelks globular. They were not frozen; and I do not doubt that their temperature was higher than that indicated by the thermometer.' The contractions were afterwards restored by a weak galvanic current. In another observation, 'I froze the water in which the eggs were placed, so that some of them were completely, and others incompletely, frozen. The frozen eggs were all more or less opaque, and had their inner sacs ruptured and emptied of yelk in various degrees, and their formative yelks lobulated and darkly granular. Those which were least frozen

were slightly opalescent only, and when allowed to thaw they contracted as before, ultimately going on to cleave in an irregular manner, the ruptures in their sacs having healed. Slighter reductions of temperatures to 40° F. and 48° F. retarded without destroying the contractions. In such cases the commencement of cleavage was delayed. By raising the temperature moderately the movements were accelerated; but at about 80° F. (it is difficult to speak with certainty of the temperature actually obtained by the object) the contractions were arrested, the yelk-ball becoming globular, and the oil-globules being scattered. Such eggs, however, soon recovered themselves when left at 58° F., and cleft in even less time than eggs did which had not been warmed. In other eggs, heated in a chamber at 102 F., the cleavage was retarded to three times the usual period, and when it took place was wanting in symmetry. The yelk began to become opalescent at about 103° F.; but a true coagulation of the albumen did not take place, the yelk being fluid and opaque. Thus a temperature too low or too much elevated retards or arrests the contractions, but they are not destroyed before commencing physical and chemical changes set in.'

"Whether the point at which the contractions of the yelk ceased was the point at which vitality left the egg, might or might not have been the fact, but it is quite evident that the egg was, at the temperatures stated, in an abnormal state, and the necessity of sustaining a temperature around the eggs of fishes between these extremes is apparent, if they are to be kept in their most favorable condition.

"Mr. Green and Mr. Wilmot both procured eggs this season from the Detroit River. Mr. Green made use of a newly devised apparatus for hatching, that proved to be a most excellent contrivance, both for the economy of space and the facility for caring for the eggs. By this method he will be enabled to hatch five or six times the quantity of eggs in the same building. The young fishes were distributed in accordance with the excellent plan adopted by the New York commissioners for supplying demands from all parts of the State, without expense, on application.

"The success attained by these persevering experiments is now complete, and the White-fish may be restored by artificial propagation, to the same extent as the Salmon, or the Brook-Trout, or the shad. As has been shown, the White-fish has advantages in this particular that the other species have not. The obstruction of streams is no obstacle in the way of their multiplication, because they have no necessity of ascending them, and, unlike the Trout and the Salmon, they cannot be suspected of eating each other.

"Attempts at feeding the young fishes have all been failures, and the only natural food that has been found in their intestines is the species of *Diatomaceæ* reported by Mr. Briggs. But as they are more vigorous and strong in the earlier stages of growth, there is not the same necessity of caring for them until they are partly grown, and they should be put into the waters they are to inhabit soon after the ovisac is absorbed, and allowed to find their natural food for themselves, just as the young shad are treated when hatched artificially.

"Artificial propagation affords advantages that compensate for all the overfishing and losses that the fish faunæ suffer from man and natural causes. The great numbers of eggs found in the ovaries of fishes in reality afford little evidence of their capacity for populating the waters. It is a fact, illustrated in nearly if not all branches of the animal kingdom, that the most fecund species do not, by any means, increase the fastest in numbers, but from the greater evils they are subject to, and the greater number of enemies they encounter, there is such a fatality during the earlier stages of growth that the losses balance the numbers produced, and less fecund species, by being better protected, equal them in numbers. The most perfect illustrations of this fact may be found among our lake fishes. The muskellunge, *Esox nobilior*, has a very large number of eggs. A cast

of the ovaries of a large female specimen, made by Dr. E. Sterling, of Cleveland, Ohio, is in the possession of the Smithsonian Institution. The ovaries measure over two feet in length, and the eggs are about the same diameter as those of the White-fish; they contain at least five times as many eggs as a pound White-fish, and yet, as regards numbers, the muskellunge is a comparatively rare fish. There are, undoubtedly, exigencies attending the egg stage of this fish that will account for this fact.

"In the case of the White-fishes, though annually depositing millions of eggs, the delicate nature of the embryo, and the numerous spawn-eaters, effect a certain balance of numbers with relation to the general faunæ of the lakes, so that, up to the time of the early settlement of the Lake region, the fish were found in great abundance. The nets now came in as an additional agent in preventing the increase, the pound-net, particularly, killing a large percentage of the fishes that had not matured sufficiently to assist the increase by depositing spawn, and in consequence the numbers of fishes were rapidly reduced.

"The care of the eggs in the hatching troughs has proved, beyond question, the frail nature of the eggs of the White-fish. They are smaller, and have a much thinner investing membrane, or shell, and have not the same enduring vitality that the ova of the Trout and Salmon have. So that in the open water of the lakes and rivers by far the greater number are lost because of the disturbance of the bottom by the autumn storms and the deposit of sediment from the muddy water, the failure of many of the eggs to come in contact with the milt of the male fish, the myriads devoured by the army of spawn-eaters, and the additional evils of pollution of the waters from the drainage of cities, manufactories, and saw-mills, and the dragging of seines over the spawning beds.

"A quantity of White-fish eggs taken from the bottom of the Detroit River, a very extensive spawning ground, while dredging in company with Mr. George Clark, at the close of the spawning season, were found to be dead and white, or so coated and stained with the black ooze that they could not have survived. In the pond on Grassy Island, where as many as ten thousand female White-fish deposit their spawn in a season, we succeeded in taking between fifty and sixty embryo fishes, by drawing a seine lined with millinet, and a diligent search through several hours at the surface in the month of April.

"In obviating all of these evils, artificial propagation asserts its advantage, and though the number of eggs that may be handled is exceedingly small compared with the millions sown by the fishes, yet the number of fishes produced may really exceed the present production in a state of nature. This assertion has ample proof in the restoration of fishes in regions where they have been nearly exterminated, and even where no change was made in the restrictions upon the fishing that might have assisted the increase.

"The experience of the past few years has proved entirely the possibility of increasing the numbers of the White-fish by artificial propagation. The running water in the troughs supplies the conditions required by the eggs; the fertilization of the ova in the pan brings every egg in contact with the milt; they lie undisturbed and free from injurious sediment or filthy water; the spawn-eaters have no access to them whatever, and the dead eggs are immediately removed from contact with the living ones; the young fish are under control in the troughs until the ovisac is absorbed, when they are ready to be placed in their natural home, the cold waters of the Northern Lakes.

"The experiments of Mr. Seth Green and Mr. N. W. Clark have reduced the loss of the eggs to an inconsiderable number, and with a small outlay of money this fish may be restored with a success equal to that of the shad in the rivers of the Atlantic coast.

"The losses in the fry stage merit consideration, though there is every evidence to believe that they are very small. One great advantage in favor of the young White-fish is its strength and vigor almost from the time it leaves the egg, and its disposition to seek the surface, as observed in the troughs and where they were seen in their natural condition in Detroit River."

DISEASES.—Nothing definite has been ascertained regarding the diseases to which White-fish are liable. A roughness, however, on the scales may be observed from about November 15 to November 20. This roughness has the appearance of small tubercles, and is most apparent on the sides toward the vent. The male fish is said to exhibit this possible symptom of disease the more plainly.

Mr. Milner's observations on the White-fish, with regard to its being infested with parasites, led him to write:

"The White-fish, as far as my observations have extended, is infested with two external and two intestinal parasites. The external ones are a crustacean, a *Lernæa*, and an annelid, the *Ichthyobdella punctata*. The lernean was found only in the Detroit River, adhering to the fish on the dorsal region, and with its bell-shaped sucker buried in the epidermal sheath of the scales. On the White-fish swimming in schools near the surface around the edge of the pond in Detroit River, it could be detected by close examination fastened to the fish. There were seldom more than four on one fish. The Lake Herring, confined in the same pond, swam in close contact with the White-fish, but in no instance, although careful observations were made repeatedly of the Herring while in the water and after capture, was the lernean found upon them. In Lake Superior they are found to be numerous on the siscowet.

"The *Ichthyobdella*, a leech of three-fourths of an inch long, grayish-white in color, with brown tesselated markings, was seen in great numbers in the month of April, while the fishermen were lifting their nets from about fifty fathoms some fifteen miles out from Kenosha, Wisconsin. They covered the nets and fishes of all species, and fell in such numbers on the deck that it became slippery, and an old coat was thrown down for the man who was lifting the gang to stand upon. They were very tenacious of life, living for a long time on the deck, and for several days in the bilge-water of the fish-boats. They were in such numbers that it was difficult to decide whether they had a preference for any species, and were found filled with blood both in the gills and while attached to the body, though it was difficult to imagine that they could fill themselves with blood from the epidermal sheath of the scales. They were thought to be most numerous on the White-fishes, as they were in greater numbers on them than on the Trout, the Lawyer, or the Cisco, the only other fishes taken.

"A prevailing but mistaken opinion in the vicinity was that the White-fish fed upon the leech. Dr. Hoy's investigations disproved the notion, and all examinations of stomach contents confirmed this fact. One of the intestinal parasites resembled the leech somewhat in form. The other was an *Echinorhynchus*. They were never found within the stomach, but always in the duodenal portion of the intestine near the mouths of the cæcal tubes."

METHODS OF CAPTURE.—The methods employed whereby the largest numbers of this fish may be taken varies in different localities. At Whitefish Point, Lake Superior, the greater part of the catch is made with pound-nets. About the Apostle Islands the gill-net is used at all times. The best grounds are along the shore from Ashland to Ontonagon. From Grand to Sauk's Island the catch of White-fish is made with pound-nets in the spring and gill-nets in the fall. At the south end of Lake Michigan there are no pound-nets; the fish, consequently, are of large size. The White-fish fishery of Saint Joseph is carried on far out in the lake, formerly nearer shore. About Little and Grand Traverse Bays all the pounds were blown away on

October 26, 1880. They were reset and were again destroyed at the end of November. From Bay View to Evanston pound-nets are used exclusively.

Across the northern end of Lake Huron, from the Straits of Mackinac to the Detour Passage, the White-fish are followed by the fishermen with pound-nets as far as twelve or more miles from shore, and with gill-nets fifteen to twenty miles. At Port Ontario, Lake Ontario, gill-nets are extensively used in the capture of White-fish, and at Wolfe Bay it is remarked by Mr. Peter Kiel that they cannot be caught with hook and line at any season of the year. Mr. Lanman says that they are occasionally taken along Madawaska River, and that he has caught them with rod and line below the falls of that river, at its confluence with the Saint John, in the early part of the summer. The same writer states that in Eagle Lakes the White-fish is caught abundantly by torch-light with dip-nets. Of its capture in the Grand Lake, Mr. Lanman writes:

"Some years since this fish was abundant in the Grand Lake, where the writer, in the month of May, saw great numbers taken out of gill-nets set for gaspereau, and thrown away by the fishermen as worthless. At the same time, the writer caught a number of them with rod and line, in one of those small pieces of water connected with the Grand Lake, usually called 'key-holes.' It is occasionally taken in the Saint John, throughout its whole extent. In the harbor of Saint John, in spring, it has been often caught in the seines and weirs with the gaspereau, and salted with that fish, because its value was not known."

The White-fish caught in Green Bay, Lake Michigan, are thus prepared for shipment, if as fresh fish: the gills and viscera are removed and the fish carefully washed.

Referring to the west shore of Lake Michigan, down as far as Manitowoc, Wisconsin, Kumlien thus writes in 1880 in regard to the White-fish market: "The demand for No. 1 White-fish is steadily increasing, and as high as seven and eight cents are often realized when the supply is not abundant. The average price for the whole season Mr. Niquette estimates will be a trifle over four cents per pound, three and a half being paid to the fishermen. The demand for fresh fish is such, and the facilities for shipping so good, that very few White-fish are salted now. In 1870 there were about 3,000 packages sent from Two Rivers, while in 1867 there were above 6,300, and for 1879 there were not over 1,000; but a much larger amount of fresh fish has been shipped. The vicinity of Two Rivers has long been a noted White-fish ground, and still keeps up its reputation; but only a few miles to the south, off Manitowoc, it no longer pays to fish for White-fish."

At Waukegan, Lake Michigan, White-fish are largely smoked. At Oswego and vicinity, Lake Ontario, no White-fish have been salted for five years. Of those shipped from Port Clinton and vicinity, at least two-thirds to three-fourths come from Canada. Five years ago not more than one-half were received for shipment from Canada. At the present time more are being sent from this place than ever. This business has steadily increased since 1855, the increase being the most striking since 1865. "At the falls, on the Madawaska River," writes Mr. Lanman, "the inhabitants take about forty barrels every autumn, which are cured in pickle for winter use."

ABUNDANCE.—The following observations on the abundance of White-fish in the Great Lakes were made by Mr. Kumlien:

At Duluth, at the extreme west end of Lake Superior, and in this vicinity, the White-fish ranks first in importance. Mr. McClau thinks that their numbers have not decreased since 1870, but that the fishing must be carried on in deeper water than was then necessary.

Three reasons are assigned for the decrease of White-fish in Huron Bay, south of Keweenaw, Lake Superior, and vicinity, during the past fifteen years: sawdust, navigation, and overfishing. The fish are here placed in a "live-box" until required for shipping. As many as seventy-two

half barrels have been taken in one pound-net at one lift (net thirty-five feet). They here rank first in importance, are abundant and very large.

Along the shore of Lake Superior, from Ashland to Ontonagon, White-fish rank first in importance. In the vicinity of Marquette the decrease of this fish, according to Parker, has been very great within the last fifteen years, and especially since 1877. At White-fish Point this species ranks first in importance.

Down Green Bay White-fish are becoming more abundant, at Guamico the proportion as compared with the abundance of Herring being about one half barrel of White-fish to fifty of Herring. Ten years ago White-fish were the most important, but have been driven from their spawning beds in the rivers by saw-dust and other causes. The largest hauls here are made by gill-nets through the ice in winter. The appearance of this fish here is very irregular, often absenting itself for several years from hitherto favorite localities. In June, 1877, Mr. Levellé, of Pensaukee, caught in one pound-net seven hundred half barrels, besides shipping a large quantity fresh. They were all No. 1 fish. As high a number as fifty barrels were taken from the net in one morning; other nets, which were set on either side of his, took no fish. Mr. Levellé chose a ledge of rock, having a light coating of mud, for the spot on which to set his net. One of the fish which he caught weighed eleven pounds; since this large catch many other attempts have been made to catch fish in the same place, but without any great success.

The most important fish on the west coast of Green Bay is the White-fish. In 1843 the principal spawning beds for this fish were in the rivers. In 1863 thirty-six barrels were taken at one lift of a pound-net; now, five hundred pounds are regarded as a very good catch. In 1878 the largest catch on record was eight hundred and fifty pounds. In 1850 the most profitable grounds of this region were in the Menomonee River, where they were taken in racks on their return from spawning. Six hundred barrels were often taken on one rack during the autumn; now, not one example has been caught in the river for twelve years. The same cause is assigned for their disappearance as from other grounds already spoken of. About 1859, and a few years previous to the introduction of the pound-net, the greater part of the White-fish was taken in seines close inshore, usually having a warp of only thirty rods. In July and August of 1879 there were large runs of small White-fish—five or six inches in length—on Peshtigo Bar; one fisherman took out several boat-loads, and, on account of their small size, was obliged to throw them away. It was thought by the fishermen that these fish had been artificially hatched by the Wisconsin State fish commission. A more sensible plan on the part of the fishermen would have been to replace them in the water to grow, finding them too small for market.

The temperature of the water is supposed to have a great influence upon the movements of this fish, especially at the time of their arrival upon the feeding grounds in spring. "In winter," says Mr. Eveland, "they seek deep water and live upon the 'winter feed'—the so-called 'White-fish worm,' which they seek upon a muddy bottom; but about the middle of June, on an average, the water becoming warm enough, they strike inshore on sandy or on slightly gravelly shoals and bars and entirely change the character of their food; at this time feeding on the 'shell feed' (small mollusks)."

Towards Cedar River the White-fish are more plentiful than between Peshtigo Point and Menomonee. They alone are taken almost exclusively in deep-water pound-nets.

At and near Green Bay City the White-fish has been for years past the most abundant species of fish. It is now, according to the fisherman's language, "played out."

This fish is first in importance in the waters at the north end of Green Bay. The principal runs occur during the spawning season. There are a great many spawning grounds in this section, espe-

cially about the islands. After spawning they retire to the deep water in the lake. In 1879 there was an increase in the catch of White-fish in these waters. A point opposite the mouth of Escanaba River is regarded as having very superior advantages for the profitable establishment of a hatchery. In 1879, near the mouth of Manistigue River, a specimen weighing twenty-nine pounds was caught.

Between Manitowoc and Whitefish Bay the White-fish is of the first importance. At nearly all the fisheries the best runs occur during August and September. A very few are taken in the spring in the pound-nets at Cedar Grove. A great many small White-fish are taken in the vicinity of Milwaukee. The White-fish ranks first in importance in this section. In 1860 the average catch was one hundred to the net; it is now not more than one-eighth of that number. Overfishing and the capture of the spawning fish are assigned as reasons for this decrease. Their size has also of late diminished, many being so small that, were the meshes of the nets not stiff from being tarred, the fish could easily escape. In this vicinity there are no spawning grounds of note.

At the south end of Lake Michigan two varieties or grades are recognized, viz, the "shore" and the "outside" fish. The latter are firmer than the "shore" grade and bear shipment with less loss. The "outside" fish are taken in gill-nets, and the others in pound-nets. The "outside" fish, moreover, has a smaller head and reddish fins. There are no spawning grounds on this coast, and no White-fish, consequently, are taken in autumn.

Between Glen Haven and Saugatuck the White-fish ranks first in importance. Capt. J. J. Brown says that at least three-fourths of the fish taken here are White-fish. He recognizes no different varieties, and knows nothing of the "blood-fish."

There has been a decrease during the last ten years in the waters between the Straits of Mackinac and the Detour Passage; the principal cause being, probably, that the fish have been disturbed there on their spawning grounds. Captain Bennett is of the opinion that fishermen should be prohibited by law from taking White-fish after the first of November. This gentleman asserts positively that some of the once most famous spawning grounds are now entirely abandoned, and he assigns the above as the cause for this desertion. Too small fish are taken by reason of the use of fine-meshed seines. North Point, Thunder Bay, is considered the best spot in that locality for the capture of the White-fish—where it ranks first in importance—and one of the best points of all the lake region. A few are caught in gill-nets in early spring, but the bulk is taken from the latter part of September until winter, the height of runs being from the 10th to the 15th of November, at which time they are spawning. It is thought that the number of nets has doubled during the last two years, and that the fish have decreased fully two-thirds since 1865. Formerly a "rig" consisted of about one hundred twelve-rod nets: now, of two hundred and fifty forty-five-rod nets. One rig has salted twelve hundred barrels in one season. Mill-refuse thrown into the streams is supposed to be a prolific cause of the decrease in abundance of this fish.

The White fish ranks first in importance in Saginaw Bay. Mr. Fitzgerald, however, says that they are annually decreasing in the river seines, estimating the yearly diminution for each seine at about fifty barrels. In 1878 three thousand White-fish were taken in the river, and in 1879, he thinks, not one dozen. Seining for White-fish in the river was formerly a very profitable business. It is still profitable outside the bay, in the lake. The best grounds are off Point Aux Barques and eastward. Here the whole fleet of Lake Huron tugs congregate at certain seasons of the year. They seem at this point to spawn more abundantly on the Canadian than on the American shore. Comparatively few are taken here during early spring, the principal season being from May to September. It is thought that the greatly increased navigation in the river has driven the White-fish out into the lake; and even there they are not as abundant as they were formerly.

About the Charity Islands, Lake Huron, White-fish rank about third in importance. The best time for fishing is in October; some are taken in May and June. Gill nets take them all the summer. About Point Sable are the most profitable fishing grounds. The deeper the water, the more abundant the White-fish appear to be. They spawn in large numbers about the islands and at Gravelly Point. It is thought by old fishermen of this region that since 1865 the decrease of this fish has been fully one-half.

In Maumee Bay, Lake Erie, the White-fish are thought to be as abundant as they ever were, though the facilities for capture are better and more extensively used than ever before. Within the last two years a steady increase has been marked, due, it is thought, to artificial propagation. About Toledo great numbers have been planted during the last few years, and the universal verdict of the fishermen is that the White-fish are on the increase in that region. In 1875 forty tons were in one day brought into the Toledo market. The spring catch is considered as of little importance.

Between the mouth of the Detroit River and Toledo, Ohio, the White-fish ranks first in importance. On this shore they are all said to be good-sized, mature fish. It is not thought that they are on the decrease to any perceptible extent. From Ottawa City westward to Port Clinton the spring catch of White-fish is very light. The fall run usually commences about the first of October. Around the Sister Islands and on innumerable reefs are excellent spawning grounds, where they are caught in small numbers by wandering gill-netters. The catch about Port Clinton for the last five years is said to have been very poor. Gill-net fishing during their spawning season and over-fishing generally are assigned as the reasons for this falling off. In 1876, Matthews & Bell, of Port Clinton, had on their warehouse floor forty-seven tons of White-fish at one time, and the next day thirty tons more. At Locust Point and Toussaint the White-fish are reported as scarce in spring. They there rank about fifth in importance at that season. The runs are very irregular, some years being fairly abundant and others very scarce.

Since 1870, in the vicinity of the Upper and Lower Sandusky Bays, the decrease of White-fish has been alarming. Its decrease, however, has been irregular, for in 1874 there was quite a large catch. Since then the decline has been greater every year.

It is thought that the spawn is now deposited in places where it becomes a prey to larger fish. Some of the best spawning grounds at present are on the reefs off North Bass and north and east of Kelley's Island; the principal portion of the reefs are in Canadian waters.

In 1846 Mr. Anthony was hired by Dr. Ackley, of Cleveland, to convey a party of students to the famous Toussaint marshes for a hunting and fishing expedition. To their surprise, they hauled up in their seine some White-fish. Further attempts were made by Mr. Anthony, aided by two Frenchmen, and in the morning, after a whole night's work, he had taken nearly fifteen hundred fine White-fish. They had never been caught on this ground before. The fish were taken to Sandusky, but the people would not believe that they had been taken near their city. In the next year a forty-rod seine was fitted out, and with it White-fish amounting to twenty-five hundred barrels when salted were caught; this was repeated the next year with a similar success. In 1849 the first pound (twelve feet deep) was set, and the result was so successful that the seine was discarded. After four years' successful fishing they moved to the south point of Bass Island and set in thirty feet of water; this attempt was successful. At that time the season lasted from September 15 to winter; now, at the same place, it only lasts for a few days in spring.

During the best fishing days of the season—in the fall—in the vicinity of Huron, Ohio, a ton of White-fish is sometimes taken from ten nets; this is above the average. They are thought to have decreased fifty per cent. since 1875. Before 1868 they appeared to be on the increase; after that year their decrease has been continuous to the present time. The diminution in their

abundance is attributed to over fishing. In heavy weather these fish leave for deep water. In the vicinity of Vermillion, Ohio, the White-fish have no spawning grounds. A great decrease in their abundance has taken place during the past few years. In 1879 thirteen nets succeeded in taking but three tons of this fish.

In Brownhelm Bay, Lake Erie, and at and in the vicinity of the mouth of Black River, White-fish rank fourth in importance. They were more abundant in 1877 than during many previous years. Between Black River and Dover Bay is a small spawning ground, on a rocky-bottomed reef. During spawning time no White-fish are taken at Black River or Brownhelm Bay. They are most abundant in this part of Lake Erie during southwest winds, when—on their way from the shore to deep water—they are caught in the pounds. At Brownhelm Bay a great number are taken in the spring at a point just above Beaver Creek. At Black River but few can be taken, because the nets can be set but a short distance out from the shore; farther to the westward, however, the nets can be set at a greater distance from the shore, by which means the catch is greatly increased.

In the neighborhood of Cleveland, Ohio, and in Dover Bay the White-fish are not very abundant, ranking about fourth in importance. The runs are irregular, the largest ones occurring in the spring, that of 1879 being the most abundant ever known up to that time. The fishermen there say that on approach of a wind storm they will run into deep water; if they are frightened when feeding or spawning they will not return to their grounds for a long while. They are taken only in mild weather. In the waters off Conneaut and Ashtabula, Lake Erie, it is supposed that White-fish are not one-third as abundant as in 1870, but since 1876 the annual decrease has not been perceptible. Near Painesville, Ohio, no spawning or feeding grounds for the White-fish have been found; but on a shoal—some miles to the east—the gill-netters take a great many during the spawning season.

Toward the east end of Lake Erie, around Dunkirk, New York, the first run of White-fish takes place early in the spring. In June, July, and the early part of August also, large hauls of these fish are made; the best time is, however, from the latter part of September until November, when a larger grade of fish, and one which is preferred for freezing, is taken. Lately (in 1880) six thousand pounds from forty nets and thirty-five hundred pounds from twenty-five nets are reported. The largest haul in 1879 was nineteen hundred pounds from one gang of nets.

At Port Ontario, on Lake Ontario, White-fish rank first in importance. Near Oswego this fish is far from being common, and never enters the river. White-fish, up to the year 1867, have been on the increase since 1855 in the vicinity of Port Clinton, especially so during the years 1865, 1866, and 1867. Since that time they have decreased in numbers to a small extent. This decrease is largely merely a supposition, arising from ignorance regarding the movements of this fish, and the application of the latest and best methods in fishing. Probably it is true that the decrease is in the number that is caught, not in the number that might be taken. In 1859, forty-nine thousand White-fish are said to have been taken at one haul; many were small and young; fully a half of this catch were thrown away before the net could be hauled in. At Stonington Beach it is claimed that seventy-five thousand fish have been taken ashore by one haul of the seine. At Chaumont, where the White-fish ranks second commercially, there has been a great decrease during the past twenty years. Now, there are no spawning grounds in the bay, the fishing necessarily being carried on outside in the lake. Formerly, in this locality, sixty to seventy men, taking three to five tons a day, were engaged in this fishery; now, sufficient fish cannot be caught to pay the men for their time and labor.

An alarming decrease is reported from Sacket's Harbor, where they are taken inside only during their spawning season. The fish caught here are usually large. In 1876 an immense school of small ones came into the harbor.

169. THE LESSER WHITE-FISHES.

By David S. Jordan.

The Musquaw River White-fish—Coregonus labradoricus.

The name "Whiting" is said by Prescott to be applied to this fish in New Hampshire. It occurs throughout the lakes of Northern New England and Northern New York, and in the Great Lakes. It is, however, not generally abundant except in the Great Lakes. It attains a smaller size than the White-fish, those seen by us rarely weighing more than a pound.

The Moon-eye or Cisco—Coregonus Hoyi.

The Moon-eye or "Cisco" of Lake Michigan has thus far been noticed only in Lakes Michigan, Erie, and Ontario. It is the smallest of our White-fish, rarely weighing over half a pound, and it is seldom taken in shallow water. It has, from its small size and rare occurrence, little economic value. Nothing distinctive is known of its food or breeding habits.

The Lake Herring—Coregonus Artedi.

This species is almost universally known as the "Lake Herring." The name "Cisco" is also often applied to it, especially about the smaller lakes, and in many regions also the name "Michigan Herring." The Lake Herring is one of the most abundant fishes of the Great Lake region, probably second only to the White-fish in importance as a food-fish. It goes in large schools, and is taken in great numbers in comparatively shallow waters. It occurs also in the lakes of British America, and probably in Northern New England and New York. Its usual length is little more than a foot. Its mouth is much larger than that of the White-fish, and its range of food is doubtless greater. It spawns in November and December, coming into shallow water for the purpose. It exists in most of the small lakes of Northern Indiana and Eastern Wisconsin (Tippecanoe, Geneva, Oconomowoc, etc.), where it is known as the "Cisco." In these lakes it usually remains in deep water until the spawning season, when great numbers come near shore to spawn. As a food-fish the Lake Herring ranks high, although considerably inferior to the White-fish.

The Blue-fin—Coregonus nigripinnis.

This species is known as the "Blue-fin" or "Black-fin." It has thus far been taken only in the deeper waters of Lake Michigan. At times it comes in considerable numbers to the Chicago market, but it is in general a rare species. It reaches a much larger size than the Lake Herring, which species it very closely resembles. Nothing distinctive is known of its food or breeding habits.

The Mongrel White-fish—Coregonus tullibee.

This species is occasionally taken in the Upper Great Lakes, where it is generally considered a hybrid between a White-fish and a Lake Herring, hence the name of "Mongrel White-fish." It is a rare fish in collections, and nothing distinctive is known of its habits. Its range is probably to the northward.

The Menomonee White-fish—Coregonus quadrilateralis.

The only name which I have heard applied to this fish is that of "Menomonee White-fish." The name of "Round-fish" is given to it by Richardson, and that of "Shad Waiter" (Winnipiseogee Lake) by Prescott. It is found in the lakes of New Hampshire, Northern New York, the Great Lakes, and northward to the Arctic Seas. In the Great Lakes it is much less abundant than the

common White-fish. Its size is less than that of the White-fish. I know nothing of its comparative value as food. The stomach of one specimen examined by me contained small *Limnæa*-like shells. Nothing definite is known of its breeding habits.

Rocky Mountain White-fish—Coregonus Williamsoni.

This species is usually known as the White-fish; in Utah as the "Mountain Herring." It reaches a length of a little more than a foot, and a weight of about a pound. It is found throughout the Rocky Mountain region, in cold, clear lakes. It is abundant in Utah Lake, Lake Tahoe, and in most of the lakes of Washington, Oregon, and Idaho. It is frequent in the market of Salt Lake City, and sometimes comes into the San Francisco market. It spawns in October and November, running from the lakes into the small streams for this purpose. As a food-fish it ranks high, being similar to its Eastern relative, *C. quadrilateralis*.

The Chief Mountain White-fish—Prosopion Couesii.

"*A specimen of a White-fish was taken in Chief Mountain Lake, writes Milner, at the eastern* edge of the Rocky Mountains, by Dr. Elliott Coues, U. S. A., surgeon and naturalist of the Northern Boundary Commission. This specimen is very different in its type of form from any species hitherto described from this continent. In Günther's arrangement of the species of *Coregonus*, it would be placed in group (*a*), with the upper jaw produced into a cutaneous appendage. In this particular it resembles *Coregonus oxyrhynchus* Lin. and *C. Lloydii* Günth. Unlike these species, it is an elongate fish, the proportion of height to length being much the same as in *C. Williamsoni* Gir. and *C. quadrilateralis* Rich.; it also resembles this type of form in the narrow supplementary bone of the maxillary, and the former species in the shape of the maxillary.

"The only previous reference to a fish supposed to be of this genus, from the Saskatchewan River, is in some remarks appended to the description of *C. labradoricus* in the "*Histoire Naturelle des Poissons.*" Valenciennes refers, in the most undecided manner possible, to a fish which he believes to be a salmonoid, and makes his diagnosis from a drawing. There is, in fact, no direct evidence in what he says to prove that the specimen was in his possession. He admits that he is "not able to determine with certainty the genus"; and, after stating that "my first impression was to make it a *Coregonus*, since I have placed the design by the side of the other species of the same genus," ends this most uncertain and undecided effort to determine its relationship, with the question, "Could one name it *Coregonus angusticeps?*"

"It may be that the specimen at hand is a fish of the species indicated in the above name, the ascribed locality heightening this possibility; but there can be no consideration of the matter that will decide it, and the name is consequently passed over. The character given of fifty-five scales in the lateral line is very far from agreeing with Dr. Coues's specimen, and, in fact, with any description of a *Coregonus* we have seen, and may indicate that the author was right in his hesitancy to decide upon the genus.

"The most marked feature is the extensive prolongation of the snout, which protrudes far beyond the opening of the mouth. The head narrows regularly toward the anterior of the frontals, where two strong angles are found narrowing the head abruptly at the point where the short supraorbitals join, and the frontals and nasals continue forward in a narrow, blade-like extension. The supraorbitals form a bold prominence at the anterior of the orbit. The maxillary is short, dilated at its posterior portion, and has a narrow supplementary bone. The premaxillaries are somewhat retroverted, and have very little width, making the muzzle thin and narrow, as it is in *C. quadrilateralis* and *C. Williamsoni*. The adipose fin is large, attached to the body almost to the posterior extremity, and is ensheathed in scales for a considerable distance from the dorsal line.

The greatest height of body is equal to the length of the head. The least height of tail is equal to the length of the snout. The lengths of the caudal peduncle, of the snout, and of the mandible are equal to each other. The width of the interorbital area is equal to the length of the maxillary.

170. THE SMELT FAMILY—MICROSTOMIDÆ.

The Smelt—Osmerus mordax.

The Smelt is found along our Atlantic coast from the Raritan River, latitude 40° 30′, to the Gulf of Saint Lawrence. The northern limit of its range has not been precisely defined, although it is known to be extremely abundant along the northern shores of New Brunswick. It is also found in many of the fresh-water lakes of Maine, New Brunswick, and Nova Scotia, where they have become land-locked, and in some instances, as in Belgrade Lake, Maine, seem to have rather been improved by the change from salt to fresh water.

The European Smelt, *O. eperlanus*, which, though very similar in form to our own, differs from it in the size of its scales, is found in Southern Sweden, as far north as Christiania Fjord district, latitude 62°, and south as far as the entrance to the river Loire, latitude 47°, ascending the Seine as high as Rouen. It is the "Stint" and the "Spearling" of Germany, the "Smelt" or "Sparling" of England, and the "Spiering" or "Spearling" of Holland. It is found in the Baltic, and, entering the Gulf of Finland, becomes a member of the fauna of Russia, and is found land-locked in cool lakes, especially those of Norway, and also in many of the lakes of Northern Germany, and even as far south as Bavaria.

The Smelt enters our rivers and brackish bays during the winter months for the purpose of spawning, and at this period is caught in immense quantities in nets and by hook and line. John Smith wrote in 1622: "Of Smelts there is such abundance, that the Salvages doe take them up the rivers with baskets, like sives"; while Josselyn, fifty-five years afterward, remarked: "The *Frost-fish* (*O. mordax*) is little bigger than a *Gudgeon*, and are taken in fresh brooks; when the waters are frozen they make a hole in the Ice, about half a yard or yard wide, to which the fish repair in great numbers, where, with small nets bound to a hoop about the bigness of a firkin-hoop, with a staff fastened to it, they take them out of the hole."

It is to be regretted that no one has made careful observations upon the beginning and close of the breeding season of this species at different points along the coast, but the spawn appears to be deposited, generally, late in the winter and early in the spring. The smelt fishery is increasing yearly in importance, owing to the greater facilities for the transportation of fish in ice. As long ago as 1853, Storer stated that in Watertown, Massachusetts, alone, about 750,000 dozen were annually taken in scoop-nets from the 1st of March to the 1st of June. Perley, writing in 1852, stated that on the Gulf coast of New Brunswick large quantities were used every season as manure, while at the fishing stations in the Bay of Chaleur it was taken in the seine and used as bait for cod. At the present time, however, there is an enormous shipment of Smelt from this region to the United States, forty car-loads sometimes being received in New York in the course of one winter. As early as 1864, according to a note from Mr. J. Matthew Jones, quantities of Smelt were packed at Halifax for shipment to the United States.

The Smelt feeds, for the most part, on shrimps and other small crustaceans.

Although on account of their great abundance they sell in the markets at a low price, they are among the very choicest of all our food-fishes. The "green" Smelts, as they are called, or those which have never been frozen, are much the more highly esteemed, especially those which come from the Raritan Bay and other points in the neighborhood of New York.

The California Smelt—Osmerus thaleichthys.

"This species," writes Jordan, "is known as Smelt, especially in those parts of the coast where the *Atherinopsis* or California Smelt is unknown. It reaches a length of six to eight inches. It ranges from Monterey to British Columbia. It does not occur in such abundance as the Surf Smelt and the Eulachon, and it has not been noticed in fresh water. Nothing is known to us of its breeding habits. It is the prey of the various predatory fish, the larger flounders, salmon, etc. It is not brought into the market in large quantities, and, being a soft-bodied fish, is not in good condition when kept long. It has, therefore, little economic value.

The Alaska Smelt—Osmerus dentex.

This species, according to Bean, occurs around the shores of Kamtschatka, and has been observed by him at Port Clarence, and by Messrs. Turner and Nelson at Port Clarence. It is similar in size and appearance to the Atlantic Smelt. It is of much importance to the Eskimos, and is dried in great quantities for use in their boat voyages. A similar species, perhaps identical, is that described by Pallas under the name *Osmerus spirinchus*. This, it is thought by Dr. Bean, may prove to be an emaciated form of *O. dentex*.

The Surf Smelt—Hypomesus olidus.

"This species is known as the 'Smelt,'" writes Jordan, "and sometimes as the 'Surf Smelt.' It reaches a length of about a foot. It ranges from the Bay of Monterey to Alaska, being especially abundant in Puget Sound and not common about San Francisco, although occasionally brought into the markets. They feed upon worms and small crustacea, and are eaten by all the large flounders and other predatory fish. They are found at all seasons, but in the month of August they go in great schools near the shore. They spawn in the surf along the shore. The females are thought to come first, and then the males. As a pan-fish this fine oily species is unsurpassed."

The Capelin—Mallotus villosus.

Distribution.—This species inhabits the North Atlantic and North Pacific. It does not occur much south of Halifax, Nova Scotia, and never approaches near the shores of New England, but is, notwithstanding, of great importance to New England fishermen. It abounds on the shores of Newfoundland and on the coasts of Labrador, and during the month of July occurs in great numbers near the Virgin Rocks, the only portion of the Grand Banks above water. It is found, also, near Greenland, and about Iceladn and Spitzbergen, and the entire length of the Scandinavian coast, from Varanger Fjord south to Christiania Fjord, latitude 58°; the species touches Denmark, but does not appear to have been observed around the British Isles. It is the "Lodde" of Norway, where it bears so important a relation to the cod fishery. According to Richardson, it has been found very far up in Carnation Gulf and Bathurst Inlet, latitude 70° north, longitude 125° west. It occurs on the arctic coast of North America, and it seems probable that its range extends also into the icy sea of Siberia, completing the circuit of the Arctic Seas.

"The first voyager who takes notice of them," writes Pennant, "is Master Anthony Parkhurst, who visited that island (Newfoundland) in 1578, and gives a very facetious account to his shipmates of his art in charming these, and another fish he calls a squid, into his power. I refer to Mr. Hackluyt, vol. iii, p. 133, for the account."

Parkhurst observes that this fish, which is like a Smelt, and is called by the Spaniards "Anchovas," and by the Portuguese "Capelinas," "commeth also in the night, but chiefly in the day being forced by the cod that would devour him, and therefore for feare comming so near the shore,

is driven drie by the surge of the sea on the pibble and sands. Of this, being as good as a smelt, you can take up with a shove-net as plentiful as you do wheate in a shovell sufficient in three or four hours for a whole citie."

In 1880 Dr. Bean found this fish abundant and in immense schools on the cod grounds of the North Pacific, and found forty individuals in the stomach of one cod of ten pounds weight.

The abundance of this fish in northern waters, and the voracity with which schools of cod follow them, have been described by many writers, by none perhaps better than by Anspach, who thus describes the appearance of Conception Bay about the year 1818:

"It is impossible to conceive, much more to describe, the splendid appearance of Conception Bay and its harbors on such a night, at the time of what is there called the Capelin Skull. Then its vast surface is completely covered with myriads of fishes of various kinds and sizes, all actively engaged either in pursuing or avoiding each other; the whales alternately rising and plunging, throwing into the air spouts of water; the codfish bounding above the waves and reflecting the light of the moon from their silvery surface; the Capelins hurrying away in immense shoals to seek a refuge on the shore, where each retiring wave leaves countless multitudes skipping upon the sand, an easy prey to the women and children who stand there with barrows and baskets ready to seize upon the precious and plentiful booty; while the fishermen in their skiffs, with nets made for that purpose, are industriously employed in securing a sufficient quantity of the valuable bait for their fishery."[1]

"The manner in which the Capelin deposits its spawn is one of the most curious circumstances attending its natural history. The male fishes are somewhat larger than the female, and are provided with a sort of ridge projecting on each side of their backbones, similar to the eaves of a house, in which the female Capelin is deficient. The latter, on approaching the beach to deposit its spawn, is attended by two male fishes, who huddle the female between them, until the whole body is concealed under the projecting ridges, and her head only is visible. In this position all three run together, with great swiftness, upon the sands, when the males, by some inherent imperceptible power, compress the body of the female between their own, so as to expel the spawn from the orifice and the tail. Having thus accomplished its delivery, the three Capelins separate, and, paddling with their whole force through the shallow water of the beach, generally succeed in regaining once more the bosom of the deep, although many fail to do so, and are cast upon the shore, especially if the surf be at all heavy. Like the common Smelt, the Capelin possesses the cucumber smell; but it differs from the Smelt in never entering fresh-water streams."[2]

"Instances are common of vast numbers of Capelin being found dead, or in a dying state, where the schools come inshore to spawn. The sandy bottom of the sloping beach is not unfrequently strewed with dead fish, and dying Capelin may be seen wandering about and spasmodically gasping in the water from which millions of the species had abstracted the oxygen necessary for their existence.

"The Capelin spawn, as is well known, on sandy, sloping beaches, but they also spawn in waters of different depths where the bottom is composed of sand. The fishermen take Capelin with their casting-nets in from fifteen to thirty fathoms, and probably also in water of much greater depth, the needed condition being a smooth, sandy bottom over which the trio engaged in spawning may 'run' touching the bottom. In the neighborhood of Baccalieu Tickle, Mr. Jabez Tilly relates that in 1864 the fishermen took Capelin for a month, from the third week in June to the third week in July, in water varying from fifteen to thirty fathoms, with the casting-net. In the second week

[1] Page 305.

[2] LANMAN: Report United States Commission Fish and Fisheries, part II, 1874, p. 225.

of July capelin spawn was brought up from the bottom in twenty-seven fathoms of water. The spawn is said by fishermen to require about fifteen to eighteen days to arrive at maturity. The young fish leave the egg after that period. They are found near the coast until about the end of December, according to the season, and the contents of the stomachs of murrs and puffins, according to Mr. Jabez Tilly, are often full of young Capelin at that season.

"At the Fishot Islands, in 1876, the Capelin were taken in deep water about the 20th of June, before they 'came in.' The appearance of schools of Capelin coming in to spawn in May, June, or July, according to the latitude of the place, has always excited astonishment at their numbers, and often, in the present day, in Conception Bay and some other noted spawning grounds, remarkable scenes may be witnessed; an idea may thus be formed of the extraordinary number of fry, serving as food, which swarm even now in the Newfoundland seas. Nor is it less easy to conceive how greatly these innumerable hosts have contributed to the drawing inshore of the deep-sea fish; first the adult fish forming the attraction, next the spawn, then the young fry, and thus continuing to the approach of winter. So great has been the importance attached to the preservation of the Capelin that legal enactments have passed the legislature of Newfoundland prohibiting the use of this fish as manure, and the public documents abound with remonstrances against this palpable abuse of one of the most important means for preserving the Newfoundland fisheries."[1]

MIGRATIONS.—In the opinion of Professor Hind the Capelin winter with the cod in the deeper portions of the bays of Newfoundland and Labrador, though in different zones of water. Cod taken through the ice in January, 1852, in Saint Mary's Bay, had undigested Capelin in their stomachs. Professor Hind remarks that an impression prevails among the fishermen that the Capelin are moving north, and that the cod are following them, but this opinion is not shared by the fishermen who have occupied the coast of Labrador for a century. They have known the Capelin as far north as Nain for many years. On the Admiralty chart of Fort Manvers, latitude 57°, longitude 62° 7′, thirty miles north of Nain, and published in 1871, Capelin Bay is the name given to an anchorage, from which it is manifest that Capelin were seen there half a century before the fishermen passed Aullik Bay, or even Cape Harrison, nearly two hundred miles to the south. The Capelin, however, is not known to the officers of the Hudson Bay Company, or to the missionaries beyond Cape Mumford.[2]

IMPORTANCE.—The Capelin are consumed in great quantities by halibut, and also by whales. In Finmark the cod fishery is divided into two seasons, the fishery which takes place early in the spawning season, and the Lodde or Capelin fishery, which occurs later, and which, when the Capelin is abundant, is of great importance.[3]

The Labrador cod fishery, at one time of considerable importance to Provincetown, Marblehead, Newburyport, and other fishing towns of Massachusetts, like the Lodde fishery of Finmark, depended entirely upon the presence of Capelin.

The Capelin is extensively used for bait in the Grand Bank fishery, especially by the French, by whom it is stated that sixty thousand hogsheads are annually taken about Newfoundland for this purpose. In Greenland the Capelin forms so important an article of food that it has been termed the "daily bread" of the natives. In Newfoundland they are dried in large quantities and exported to London, where they are sold principally in the oyster shops.[4]

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[1] HIND: Fishery Clauses of the Treaty of Washington, 1877, p. 134.
[2] HIND: *Ibid.*, part ii, p. 70.
[3] Report United States Commission Fish and Fisheries, part v, 1879, p. 709.
[4] LANMAN: *Ibid.*

THE EULACHON—THALEICHTHYS PACIFICUS (Richardson) Girard.

This species, common in the North Pacific, resembles the Capelin, and is usually known by the Indian name "Eulachon," or "Oulachan," more commonly pronounced "hoolakins" by the English at Victoria. Those salted and sent south are commonly called "Candle-fish" by the trade. In the Columbia River and elsewhere southward it is known as "Smelt," being confounded with the other species. It reaches a length of less than a foot. It ranges from Oregon northward to Kamtchatka. It occurs in some abundance in the Columbia River, where little notice is taken of it. In Frazer River and streams to the northward it runs in enormous numbers in spring. The Eulachon run up the rivers and deposit their spawn on gravel beds at no great distance from the mouth of the stream, probably not above thirty miles. Their run is from the last of March to the middle of May, probably varying in different streams. During the run they are beset by all sorts of enemies—halibut, sharks, sea-birds, Indians, porpoises, and all manner of predatory fish, some of which chase them in the ocean only; others pursue them up the rivers. Even the sturgeons and the rays have their stomachs full of them.

The Eulachon is greatly valued on account of the oil which permeates its flesh. As a pan-fish it has no superior. A factory has been established on the Noss River for the manufacture of eulachon oil, which is intended to be used as a substitute for cod-liver oil. It has the drawback of becoming solid and lard-like at ordinary temperatures.

"Nature," the chief London journal of science, stated, May 12, 1881: "A new medicinal oil has just been introduced into this country by Messrs. Burgoyne & Burbridge, the well-known chemists of Coleman street. It is known as Oolachian oil, and is said to be scarcely distinguishable from cod-liver oil. It is obtained from a fish called by the North American Indians 'Oolachan,' or 'Candle-fish,' from the fact that when dried the fish itself can be used as a candle, on account of the large quantity of oleaginous matter it contains. . . . In America the oil has already a great reputation as a valuable and efficient substitute for cod-liver oil, and there is every probability, as it becomes known in this country, of its taking a prominent place as an important medicine." Diligent inquiry fails to bring to light evidences of any extensive use of this oil as yet in the United States.

171. FAMILIES RELATED TO THE SALMONIDÆ.

THE SCOPELUS FAMILY—SCOPELIDÆ.

The species of this family are small and pelagic, and are found throughout all the temperate and tropical seas. They are so numerous that the surface net, when used in a night of moderate weather, in mid ocean, scarcely ever fails to inclose some specimens. They come to the surface at night only; during the day, in very rough weather, they descend to depths where they are safe from sunlight and from the agitation of the water.[1]

In the Western Atlantic there are five or six species, which are catalogued in the check-list. In California there is only one, *Myctophum crenulare*, a single specimen of which was taken from the stomach of an albicore at Santa Barbara.

THE HANDSAW FISH FAMILY—ALEPIDOSAURIDÆ.

The fishes of this family inhabit very deep water, and are never seen at the surface. The Handsaw Fish of the Pacific, *Alepidosaurus borealis*, is occasionally found along the coast from

[1] GÜNTHER: Study of Fishes, p. 585.

Monterey to Kamtchatka. The Atlantic species, *A. ferox*, very closely allied to, if not identical with, its ally in the Pacific, is found in great numbers on the off-shore banks, being frequently brought up on the lines of the halibut trawl fishermen from a depth of one hundred and fifty to three hundred fathoms. It is one of the largest and most ferocious looking of the deep-sea fishes, growing to a length of six feet, its mouth provided with double rows of sharp, lancet-shaped teeth, a half to three-quarters of an inch in length. They are very slender and lithe in form, and are the personification of voracity. Günther states that from the stomach of one example have been taken several cuttle-fishes, crustaceans, and sea-squirts, a young Brama, twelve young boar-fishes, a horse-mackerel, and one young of its own species. Nothing is known of its breeding habits. Its only importance to the fisheries lies in the fact that it cumbers the hooks of the fishermen.

The Alepocephalus family—Alepocephalidæ.

This family is represented in the deep water of the Western Atlantic by two species, *Alepocephalus Bairdii* and *A. Agassizii*, of each of which single specimens have been obtained on the off-shore banks, a magnificent fish, attaining the length of at least three feet, shaped like a salmon, covered with thin silvery scales. Only one other species of the genus is known—a rare fish from the Mediterranean.

The Paralepis family—Paralepidæ.

These are small, pelagic fishes, occurring in the Mediterranean, Atlantic, and Pacific. In our waters there are three species: In the Atlantic, *Paralepis borealis*, a Greenland form, of which we have seen one specimen from the Gulf of Saint Lawrence; in the Pacific there are two, each known from a single specimen, *Sudis ringens*, from the Santa Barbara Channel, and *Paralepis coruscans*, from the Straits of Fuca.

The Snake-fish family—Synodontidæ.

The family is represented on our Atlantic coast by three species, on the Pacific by one, *Synodus lucioceps*, which is closely related to the Atlantic species, *S. fœtens*. The Pacific species occurs from San Francisco southward, and is occasionally eaten. The Atlantic forms occur in the West Indies and range north to Cape Cod, but are of no economic importance.

R.—THE HERRING TRIBE.

172. THE HERRING—CLUPEA HARENGUS.

ABUNDANCE AND IMPORTANCE.—The Herring is beyond question the most important of food-fishes. Distributed, as it is, throughout the whole of the North Atlantic, it affords occupation, during a portion of the year at least, for immense fleets of fishing boats, and, according to the estimate of Professor Huxley, the number taken every year out of the North Sea and Atlantic is at least 3,000,000,000, with a weight of at least 1,500,000,000 pounds. This estimate is perhaps more likely to be too low than too high. According to the statement of Carl Dambeck, given in the United States Fish Commission Report, volume 3, page 21, the average yield of Herring in Norway from 1850 to 1870 amounted to 1,452,000,000 pounds. Widegren[1] estimates that the total yield of Herring on the Swedish coast of the Baltic amounts to 300,000,000 pounds. Holdsworth placed the yield of Scotland in 1873 at 188,000,000 pounds, their capture requiring 15,095 boats with crews of 45,494 men. In the same period in the English fisheries he states that 15,331 boats were used. He gives no estimate of the yield, but it is probably not very different from that of Scotland. France, Ireland, and Belgium have also herring fisheries of considerable extent, and Germany in a less degree. In 1874, according to compilation and estimates of Professor Hind, 200,000,000 pounds of Herring were taken in the waters of British North America, and in 1880 nearly 43,000,000 pounds were obtained on the east coast of the United States.[2] Summing up the aggregate of these statements and estimates, and allowing to Ireland, Belgium, Germany, and France a product equal to that cited of Scotland, we have an aggregate of 250,000,000 pounds. This total is not presented as an item of statistical information, but simply to emphasize by way of illustration the statement made at the beginning of this paragraph.

Commenting upon the supposed injurious effect of the fisheries upon the abundance of this fish, Professor Huxley in his well-known lecture upon the Herring, delivered at the International Fishery Exhibition at Norwich in 1881, remarked as follows:

"It is said that 2,500,000,000, or thereabout, of Herrings are every year taken out of the North Sea and the Atlantic. Suppose we assume the number to be 3,000,000,000, so as to be quite safe. It is a large number, undoubtedly, but what does it come to? Not more than that of the Herrings

[1] United States Fish Commission Report, part iii, p. 33.

[2] The Herring appears to have been one of the most conspicuous fishes in the Western Atlantic at the time of the discovery and early exploration of America, as the following extracts from the voyages of early navigators will show:

Josselyn wrote in 1675: "The Herrin, which are numerous, they take of them all summer long. In *Anno Dom.* 1670, they were driven back into *Black-Point* Harbour by other great fish that prey upon them so near the shore that they threw themselves (it being high water) upon dry land in such infinite numbers that we might have gone up half-way the leg amongst them for near a quarter of a mile. We used to qualifie a pickled *Herrin* by boiling of him in milk."

John Smith, in 1631, remarked: "Herring, if any desire them, I have taken many out of the bellies of Cods, some in nets; but the Salvages compare their store in the sea, to the haires of their heads: & surely there are an incredible abundance upon this Coast." And again: "Of Herrings, there is great store, fat, and fair; & (to my minde) as good as any as I have seene, & these may be preserved, and made a good commodity at the Canaries.'

which may be contained in one shoal, if it covers half a dozen square miles, and shoals of much larger size are on record. It is safe to say that, scattered through the North Sea and the Atlantic, at one and the same time, there must be scores of shoals, any one of which would go a long way toward supplying the whole of man's consumption of Herrings."

NAME.—So well known was the Herring from the earliest days to the inhabitants of Northern Europe and to their descendants who migrated to the western shores of the Atlantic, that one name serves to designate the fish in the languages of a majority of the peoples to whom it is known. Its name in English, German, and Dutch, though differently spelled, is pronounced in exactly the same way. To the Scandinavian tribes it is known by the name "Sill." France in the name *Clupée* employs a form of the Latin name for fishes of this group by which the same fish is known to these nations when described in the language of their men of science. There are certain local names for the Herring which are used not to replace the general one, but to designate certain conditions and ages. To this class belongs the name "Sperling," employed by our own *fishermen of Cape Ann to denote the young Herrings. Corresponding to this name the word "Strömming"* is used in Sweden. British fishermen, according to Huxley, distinguish four states of the Herring: (1) "Fry," or "Sill," for the young fish when not larger than sprats; (2) "Maties," a name which is a corruption of the Dutch word for a maiden; Herrings in this class are larger than fry, but with undeveloped roe or milt; (3) "Full," fish with larger developed roe or milt; and (4) "Spent" or "Shotten," fish which have recently spawned. "Maties," when gorged with their favorite food, small crustaceans, are called by the Scotch fishermen "Gut-pock" Herrings. In Sweden, according to Widegren, the following names are known in the trade: "Norwegian Herring," "Gråben Herring," "Fat Herring," "Gottenburg" or "Bohuslän" Herring, "Kulla Herring," "Bleking Herring," "Small Herring," "Anchovies," "Skarp Herring," "Spiced Herring," etc.[1]

These names are cited to indicate how many variations are customarily made upon the well-known name of Herring. In the United States there are few trade names for this fish, though a large portion of our Herring pass from producer to consumer under a name which is intentionally deceptive, that of "French Sardine," and a few are canned in spices and sold under the still more imaginative name of "brook" and "sea" trout. "Bloater," "Digby Chicken," and "Hard Herring" are other trade names used on this side of the Atlantic, the significance of which will be explained in the paragraph relating to "economic uses."

Small Herring are frequently called "Brit" by the fishermen of Eastern New England. "Anchovy" is another name for these small fish—still in use among our fishermen—and had its origin in one of the devices of trade.

By far the most confusing congeries of names, however, is to be found in the literature produced in such lavish quantities during the past twenty years by the Scandinavian naturalists who have been attempting to reconcile with fact the theories prevalent among fishermen and others in Northern Europe concerning the movements of the different schools of Herring and the race characteristics and habits which were supposed to characterize them.

In the "Preliminary Report for 1873–'74 on the Herring and the Herring Fisheries of the West Coast of Sweden," by A. V. Ljungman,[2] are given numerous names of this sort, such as "Boundary Herring," "Grass Herring," "Great Herring," "Norwegian Winter Herring," "Norwegian Fall Herring," "Old Herring," "Real Sea Herring," "Cattegat Herring," "Sea Herring,"

[1] United States Fish Commission Report, part vi, p. 124.

[2] Translation in United States Fish Commission Report, part iii, 1876, pp. 123–167.

"Fjord Herring," "Scotch Dutch Herring," "Lard Herring," "Half Herring," and "Tender Herring." In this report Mr. Ljungman attempted to distinguish and described at least four varieties, and in so doing was much more conservative than his predecessor, Professor Nilsson, (?) who in the year 1832 described, under binomial names, as distinct species eight of the forms known in his country under separate popular names. In a later report on the salt-water fisheries of Bohuslän, published in 1878,[1] Mr. Ljungman, who had, in the six years intervening between this date and the writing of his first essay, devoted much time to the study of the subject, appears to have abandoned his early idea, since he makes no attempt to distinguish the races, and simply announces himself as maintaining that "more than one race of Herrings may be found in one and the same place."

GEOGRAPHICAL DISTRIBUTION.—The Herring is found in the temperate and colder parts of the North Atlantic. On the west its range extends south to Sandy Hook, at the entrance of New York Harbor, where they are found occasionally in midwinter, and on the north as far as Northern Labrador, diminishing in numbers perhaps toward the northern extreme. On the east its southern limit is in the vicinity of the Bay of Biscay, while northward it is found in the White Sea and on the southern shores of Spitzbergen. It of course does not enter the Mediterranean, though it is abundant in the North Sea and in the Baltic. Huxley hazards the conjecture that it perhaps inhabits some parts of the North Sea, and states that there is a very similar, if not identical, species in the North Pacific. His surmise as to the identity of the Pacific Herring with that of the Atlantic is not confirmed by the recent careful explorations of Dr. Bean in that region. The fish which he had in mind is probably *C. mirabilis*.

On our own coast Herring are not known to enter water which is in the least degree brackish, except occasionally in the spawning season in Saint Andrew's Bay, where the admixture of fresh water is but slight. According to Professor Huxley, Herrings spawn freely not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water of which is quite drinkable and is inhabited by fresh-water fish.

Ljungman[2] cites instances in which Herrings are said to have ascended rivers in Sweden and Germany to a distance of several miles. The same author, however, seems inclined to believe that the Herring is far from having a predilection for fresh water, and that the few instances in which they have been observed spawning in brackish waters have been purely incidental and induced by the fact that suitable spawning places could not be found in waters of an ordinary degree of saltness.

The temperature preferred by the Herring has been more carefully determined in Europe than here. The observations of the Scotch and Dutch meteorological societies have demonstrated that the temperature of the water most favorable to the summer herring fisheries of their respective countries is about 55°.4 F., though during the Scotch winter fisheries the temperature ranges from 40°.1 F. to 41°.9 F., and during the Norwegian spring herring fisheries it ranges from 37°.4 F. to 39°.2 F. Commenting upon these figures, Ljungman remarks:

"There is good reason to suppose that the Herrings prefer a certain even temperature of the water, and that they consequently avoid too warm or too cold water. This degree of temperature, however, differs greatly according to the different locations, fisheries, and races of Herrings. The fishing for spawning Herrings is, for example, on the east coast of Scotland, going on at a season of

[1] Translation in United States Fish Commission Report, part vi, pp. 143–220.

[2] Report United States Fish Commission, part vi, p. 177.

the year when the temperature of the water is very high (from the middle of July till the middle of September), or very low (January to March). The observations of the Scotch and Dutch meteorological societies made during the Scotch and Dutch summer herring fisheries have shown that the temperature of the water most favorable to these fisheries is about 13° C. (55°.4 F.). During the Scotch winter fisheries, however, the temperature of the water ranges from 4°.5 C. to 5°.5 C. (40°.1 F. to 41°.9 F.), and during the Norwegian spring herring fisheries it only ranged from 3° C. to 4° C. (37°.4 F. to 39°.2 F.). But our observations are still so incomplete, and relate so exclusively to the spawning Herrings, that it is impossible to say anything with absolute certainty excepting the fact that the Herrings, when the temperature of the surface waters is either too high or too low, go to deeper waters."

The theory advanced by Ljungman in this last sentence is perhaps a little premature. Is it not supposable that local races of Herring exist and perform the various functions of life in totally different scales of temperature? This is undoubtedly the case with sedentary fresh-water species, such as the black bass, which, in its extreme northern range in North America, lives in waters which in midsummer are colder than those which southern fish ever experience even in winter. This view is not presented as a new one, but simply for the sake of introducing the illustration.

MIGRATIONS AND MOVEMENTS.—In Ljungman's report on the fisheries of Bohuslan, already quoted from,[1] is given the following recapitulation of the different scientific theories that have been in the past and are now heard concerning the migrations of the Herrings:

"In briefly recapitulating the different scientific theories regarding the migrations of the Herrings, it will be found that they may all be arranged under the following heads:

"*a*. The theory of a central race of Herrings, according to which all Herrings which are in the world belong to one great central race, from which all kinds of Herrings, both great and small, come. This theory is varied as follows:

"1. This central race of Herrings is supposed to live in the northern Polar Sea, from which large schools emigrate every year to those coasts where herring fisheries are carried on (Anderson, Pennant, and others).

"2. This central race of Herrings is constantly moving through the Northern Atlantic Ocean in a circle, whose extent is regulated by the declination of the sun (Gilpin).

"3. Besides this great central race of Herrings living in the Northern Atlantic Ocean, causing the great herring fisheries, smaller local races having separated in course of time, causing the smaller coast fisheries (Lundbeck).

"According to the first two of these three theories there would be no regular migrations, whilst such would take place according to the third.

"*b*. The theory of separate races of Herrings, according to which the different fisheries are caused by separate races of Herrings, each having its own locality. This theory is varied as follows:

"1. The theory of a coast race of Herrings, considering the Herring exclusively as a bottom fish. This may again be subdivided:

"*a*. Some suppose that there is only one local race of Herrings in every place, which, if not driven away by human agencies, always stays near the coast. There is consequently no difference between coast Herrings and sea Herrings, and there are no regular migrations (Nilsson).

"*b*. Others think that more than one race of Herrings may occur in one and the same place. There is consequently a difference between coast Herrings and sea Herrings, and there are regular

[1] Report, United States Fish Commission, part vi, p. 218.

migrations; but the proper homes even of the sea Herrings are the deep valleys on the bottom of the sea near the coast (Axel Boeck).

"2. The theory of a sea race of Herrings, considering the Herring as a surface fish. This theory is also subdivided:

"*a*. Some deny the occurrence of more than one race of Herrings in one and the same place, the difference between coast Herrings and sea Herrings (littoral and pelagian Herrings) and regular migrations (G. O. Sars).

"*b*. Others maintain that there is a relative difference between coast Herrings and sea Herrings, that more than one race of Herrings may be found in one and the same place, and that the great schools of Herrings migrate regularly (A. V. Ljungman)."[1]

This table is quoted as an illustration of the uncertainty which even to the present time exists concerning the migrations of this fish—an uncertainty which in all probability will never be removed. It is safe, however, to say that the theories enumerated in catalogue *a* had been long since abandoned by all scientific thinkers. The views of Sars and Ljungman that the Herring is practically a surface fish, not usually descending to great depth, perhaps never more than one hundred fathoms below the surface, are supported by many arguments of analogy; at any rate, they agree with what many investigators believe to be true concerning certain fish with some similar habits, such as the mackerel and menhaden. On the other hand, Herrings are known to occur off the Newfoundland coast, according to Mr. Earll, at a depth of fully one hundred fathoms, and there is no reason why they may not descend to still greater depths.

"If you read," writes Professor Huxley, "any old and some new books on the natural history of the Herring, you will find a wonderful story about the movements of these shoals: how they start from their home in the Polar Seas, and march south as a great armada which splits into minor divisions—one destined to spawn on the Scandinavian and one on our own shores; and how, having achieved this spawning raid, the spent fish make their way as fast as they can back to their arctic refuge, there to repair their exhausted frames in domestic security. This story was started in the last century, and was unfortunately adopted and disseminated by our countryman Pennant. But there is not the least proof that anything of the kind takes place, and the probabilities are wholly against it. It is, for example, quite irreconcilable with the fact that Herring are found in cods' stomachs all the year around. And the circumstance to which I have already adverted, that practiced eyes distinguish local breeds of Herrings, though it does not actually negative the migration hypothesis, is very much against it. The supposition that the Herring spawn in the north in the early spring, and in the south in the autumn, fitted very well into the notion that the vanguard of the migrating body of Herrings occupied the first spawning ground it reached, and obliged the rest of the horde to pass on. But, as a matter of fact, the northern Herrings, like the southern, have two spawning times; or perhaps it would be more correct to say that the spawning time extends from autumn to spring, and has two maxima—one in August–September and one in February–March."

Discussing the causes of the movements of the Herring schools, Professor Baird in 1877 wrote as follows:

"Although the movements of the Herring appear to be very capricious, they are doubtless governed as much by well-defined laws as any other portion of creation, although we are yet far from understanding fully the conditions which control their actions. They sometimes frequent a portion of the European coast for many successive years, and then abandon it gradually or suddenly, presenting themselves usually at the same season in some far remote locality. Sometimes

[1] Report United States Fish Commission, part iv, p. 178.

a wind blowing on shore will favor their inward migration; at other times it appears to have a directly opposite effect. Even when they reach the portion of the coast for which they are bound, the facilities of their capture depend upon meteorological conditions; and the Scottish Meteorological Society has been engaged for several years in ascertaining what these are, and how they may be best applied by the fishermen.[1]

[1] "The inquiry was restricted at first to the east coast of Scotland, and to pond-fishing districts therein, viz, Wick, Buckie, Peterhead, and Eyemouth, the last including the fishing ports of Dunbar and Eyemouth, Berwick and North Sunderland. Copies of the weekly returns sent to the fishery board from these districts during July to September, the season for the herring fishing for that part of Great Britain, for six years, beginning with 1867 and ending with 1872, giving the catch per week, the number of boats out in each district, were extracted from the reports, and an average of these six years calculated at several of the stations. These were finally compared day by day with two series of sea temperatures; one taken off Harris, and the other near Edinburgh.

"The temperature of the sea was found to rise very rapidly about the middle of July, and to keep oscillating slightly about a uniform temperature of 56° until the 13th of August, when it rapidly rose to the annual maximum, namely, 57°.2, and ranged relatively high until the first of September. This period of highest annual temperature, *namely, from the middle of July to the first of September, was found to be coincident with the fishing season in the* northern districts of Scotland; and the period when the temperature rises to the absolute maximum is farther coincident with the date of the largest catches during the fishing season. The committee, however, consider it premature to lay great stress on the striking coexistence of these facts, since it is impossible, without further statistics, to say whether these relations are of a permanent character. The fishing season did not begin until the sea temperature had risen to about 55½° in July, nor did it continue after it had fallen below 55½° in September.

"An important omission in these tables is, that they do not show whether they indicate the surface or bottom temperature of the sea, the difference in this respect being very appreciable. Another omission is, as to the relation between the spawning season of the Herring and their shoreward movement. Along the coast of the United States, the great spawning ground of the sea Herring is off the southern end of Grand Manan, where the surface and bottom temperatures sometimes differ at the spawning season by as many as five or six degrees.

"An important relation was also observed by the committee between the exceptional atmospheric temperatures and the migrations of the Herring, the fishing season beginning much later in the year, when the summer temperatures are low, than when they are high. As regards the relation between barometric observations and the fisheries, it appears that during the periods when good or heavy catches were taken, in a great majority of cases the barometer was high and steady, the winds light or moderate, and electrical phenomena wanting; when the captures were light, the observations often indicated a low barometer, strong winds, unsettled weather, and thunder and lightning.

"In conclusion, the committee recommend that, in further elucidation of the subject, steps should be taken to obtain information which may lead to the solution of the following queries:

"1. What determines the time of the commencement of the fishing?

"2. What determines the fluctuations in the catches of Herring in different districts, or in the same district on different days?

"3. What causes the absence of Herring during some seasons from certain districts of the coast?

"4. What determines the ending of the fishing season?

"The information required demands—

"1. An extension of the area examined, so as to include the Moray Firth, the Shetland, Orkney, and Hebrides Islands, and the west coast of Scotland.

"2. Daily returns of the number of boats fishing and the catch.

"3. The erection of self-registering sea thermometers at different points on the coast, similar to those now in operation at Peterhead Harbor.

"4. Thermometric observations taken by the fishermen themselves over the grounds fished; as it is only by the observations of numerous thermometers in continuous immersion that we can hope to obtain accurate information regarding those currents of cold and warm water round our coasts which are often found to interpenetrate each other, and which are supposed, with apparently good reason, to influence greatly the migration of the Herring. It is said that the Dutch fishermen derive valuable practical advantages from a system of this kind, and there can be no doubt that favorable results might confidently be looked for if a similar system were generally adopted by our fishermen.

"It is an interesting fact in the natural history of the Herring that, while the season for their capture is quite definite and generally uniform at any one point, it varies on different parts of the coast; thus, on the east of Great Britain, from Shetland in the north to Flamborough Head in the south, it occurs in July, August, and September, and a little earlier in the north than in the south. At Yarmouth the Herring season is in October and November; off the Kentish coast, in November and December; along the south coast of England, from October to December; off Cornwall, in August and September; in the North Channel, in June and July; and in the Hebrides, May and June.

"It is suggested by the Scottish committee in their report that when the periods of migration on all parts of the British sea-coast will have been calculated as closely as in Scotland, these will be found to bear a critical relation to the annual epochs of the temperature of the sea. This gives a renewed importance to the inquiries undertaken by

"In reference to the capture of Herrings far out at sea, Holdsworth refers to the fact that the Lowstoft herring fishery commences early in the spring, fifty to sixty miles from the coast, when the fish are poor and the roe very little prominent. The fishermen, however, accompany the schools in their slow progress to the coast; and when they get within a few miles the fish will be fattened up and the roe is in a much more advanced condition."

In his latest report, already several times quoted, Ljungman discusses the annual migrations of the herring schools and their causes:

"It has been mentioned before that the young Herrings begin to wander about at an early age, chiefly to seek food or shelter from their enemies, or possibly more agreeable places of sojourn. It has frequently been observed that the young Herrings, as they grow up, leave the shallow waters near the coast and go into deeper waters farther out towards the ocean, whence, after a while, they return to the coast in company with the older Herrings. The knowledge of the details of these migrations is, like our knowledge of their physical and biological causes, so limited that very little can be said regarding them.

"Regarding the coming of the Herrings from the sea to the coast, we only know that during the spawning season they generally approach the spawning places in dense schools, coming from the north, and that when visiting the coast for other purposes the schools are smaller and more scattered, extending over a larger stretch of coast, and come both from the north and the south. Those Herrings which come to seek food generally remain for some time in the outer waters before they come near the coast, and their visits are neither as regular nor as long as when they come to spawn. But even the great mass of Herrings does, during the spawning season, not remain near the coast longer than one or two months, exceptions from this rule being rare indeed. Herrings which have thus remained near the coast over their regular time become almost entirely worthless. During the last great Bohuslan herring fisheries this seems to have occurred more frequently.

"In approaching the coast the Herrings generally begin at a certain point, spreading from it either to the left or right, or in both directions, influenced in this by the weather, the currents of the sea, and the nature of the bottom. The Herrings do not like to visit the place where they have spawned a second time. It has also been noticed that the large Herrings do not go as high up the fiords as the small ones, and that when the spawning season comes in winter or spring the large Herrings spawn before the small ones, whilst when the spawning season comes in summer or autumn the small or younger Herrings spawn before the larger and older ones. After spawning, the Herrings have often been observed to go nearer the coast than before spawning; fishing with drag-nets may therefore be carried on long after fishing with stationary nets has ceased, as the 'empty' fish (those that have spawned) do not easily enter a stationary net.

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the United States Signal Service and the Fish Commission, on the American coast, in the way of determining of the sea temperature, etc., as connected with a very important branch of our domestic industries.

"In this connection we may state that the spawning season of the Herring, and the time of its catch, vary remarkably in different portions of our own coast. Thus, in parts of the Bay of Fundy and in the Gulf of Saint Lawrence it takes place in May and June, as in the Hebrides; at the Southern Head of Grand Manan, the great spawning ground, it occurs in September, commencing possibly in August, and extending into October; taking place later and later in the season as we proceed south. At the most southern point at which the Herring is positively known to spawn, namely, off Noman's Land and possibly Block Island, this does not occur until December and January.

"From this we may draw the inference that a certain minimum of temperature, rather than a maximum, is needed for the operation in question; and this occurring in the autumn, that the proper temperature is reached later and later as we proceed southward.

"It is to be hoped that the temperature observations now being made by the United States Fish Commission and by the Signal Service may enable us to solve these problems and to co-operate with our Scottish scientific brethren in getting at the true relation between physical conditions and the movements of such important food-fishes as the Herring, mackerel, cod, etc.—*Report of the Scottish Meteorological Society.*

"The going out of the Herrings is generally a much quicker process than their coming in, and as it is more difficult to catch Herrings whilst they are leaving the coast we know very little about it. After the Herrings have left the coast they do not stay outside any length of time, but immediately go out to sea to seek food and enjoy the greater protection which the deeper water affords. When the Herrings have been to the coast for the purpose of spawning they generally leave the coast in a northerly direction.

"With regard to the extent of the annual migrations of the Herrings I have already mentioned the different opinions, and I will only add here that the larger a school of Herrings is the greater will be the extent of territory where they must seek their food, and the farther from the coast must they extend their migrations. It is not known from direct observations how far the largest schools of Herrings extend their migrations, but certainly much farther than Macculloch, Nilsson, Boeck, and their followers assert.

"The annual migrations of the Herrings may be influenced by physical causes both as regards their time and their direction. It is well known that favorable, mild weather accelerates, whilst bad weather retards, the approach of the Herrings to the coast, and that wind and current may bring a much greater number of Herrings to one part of the coast than to another near it. The general rule, however, is that the Herrings, when coming in to spawn, visit the place where they were born. When the Herrings come in to seek food they will generally go to those waters where they have been accustomed to find food in the greatest abundance; those physical causes, therefore, which have an influence on the occurrence of food will also influence the direction of the Herring's migrations, as I have had occasion to remark before.

"The annual migrations of the Herrings are chiefly caused by the desire to propagate the species and to seek food. For spawning, the Herrings need a suitable bottom for depositing their eggs, a bottom which also must contain a sufficient quantity of food for the young Herrings and afford shelter for them. All these requirements are only met near a coast. Even if Herrings, as has sometimes been said, not without a show of reason, spawn on the Dogger Bank, or other still more distant banks in the North Sea, this does not disprove our assertion, for it is doubtless only the greater ease with which the young fish can reach the coast from these banks which has made it possible for the Herrings to spawn there.

"The grown Herrings must again go to the ocean to seek their food, which they chiefly find in the currents and those waters which come from the Polar Sea. In some places, however, they find the required food during some part of the year near the coast; and thus there may be fishing towards the end of summer and the beginning of autumn, as on the western coast of Norway, or during autumn and winter, as on the coast of Bohuslan. The influence which the desire for food exercises on the annual migrations of the Herrings has sometimes been overrated, so that it has occasionally been considered as the chief cause, even in cases when the desire to propagate was undoubtedly the principal cause.

"As the spawning Herrings, on account of their being packed more closely together and on account of the steady course which they pursue, are more exposed to the persecutions of their enemies, and as this danger of course increases the nearer they get to the coast, they generally go into deep water immediately after having spawned, in order to find the necessary shelter, and leave the coast much quicker than they came. The larger Herrings seem likewise to thrive better in the open sea than near the coast, and consequently do not stay there longer than is absolutely necessary. Neucrantz, however, goes too far when he supposes that the Herrings leave the coast only to escape unpleasant physical conditions; for instance, cold or violently agitated water. It has already been mentioned that want of space or the persecutions of enemies have in former

times by some been considered as the chief causes of the annual migrations and regular coast visits of the Herrings. Such opinions are, however, no longer entertained, and therefore cannot claim our attention."

PERIODICITY OF THE ABUNDANCE OF HERRINGS ON THE EUROPEAN COAST.—So far as is known, the abundance of Herrings in the Western Atlantic has been constant during the past two centuries; at the same time so little is our fishing population dependent on the herring fisheries when compared with that of Northern Europe that variations in abundance not being regarded as national disasters would, except, perhaps, in the case of Newfoundland, scarcely have been placed definitely upon record. Concerning the periodicity of the herring supply in Northern Europe Professor Baird writes:

"Among the various problems of interest in Northern Europe there are few of more economical importance than that connected with the movements of the Herring, a fish which in some years furnishes a supply of almost millions of barrels, and in others a few thousand are all that can be secured. While the cod always maintains its numbers and comes with unerring regularity in winter to spawn in the Loffoden Islands, and is found in moderate numbers on the coast throughout the rest of the year, the Herring appears and disappears without any, at present, intelligible cause. This variation in abundance is by some ascribed to a total disappearance from the coast, while others believe that it remains within a hundred miles of the Scandinavian shore, far out in the deep water between the banks of the North Sea and the coast of Norway, but that, owing to some peculiarity of temperature, currents, or possibly tainting of the water by the abundance of the so-called gurry, or offal, from the herring and cod fisheries, it is kept away. Down to a late period of the preceding century the Herring appeared in immense numbers with tolerable regularity, then left the coast, and did not return till 1808—a lapse of twenty years. For sixty-two years after that it presented itself with unfailing certainty, so much so that all fears of a possible diminution were banished; but since 1871 it has almost disappeared from the usual fishing stations, a few thousand barrels being the maximum catch where a million or more was the rule. This is what is known as the spring herring. The so-called 'great' Herring fishery has since 1870 attained a considerable importance at a distance of from five hundred to seven hundred miles from the spring herring locality. This diminution of the spring herring fishery of Scandinavia was for a few years of considerable advantage to the American fishery interest."

The following memoranda, communicated in 1878 by Mr. Joshua Lindahl, will serve to show the periodicity in the movements of the Herring in Europe:

"Before the sixteenth century no records were kept of the fisheries. As, however, both king and church had some income from taxation and tithe on the Herring, it has been possible to ascertain that such fisheries have existed periodically ever since the beginning of the eleventh century. Before that time the archipelago was hardly inhabited, and the fishing seems not to have been of any importance but to the scanty population on the fiords, who had too primitive implements for capturing large quantities of fish, and no means of preparing the article for a distant market. The following is a list of the herring periods of which we have any knowledge:

"1. About the year 1020.

"2. In the latter part of the twelfth century.

"3. From about 1260 to about 1341, thus lasting more than eighty years.

"4. About the middle of the fifteenth century.

"5. From 1556 to 1590, thus lasting for thirty-five years; interval to next period, sixty-nine years.

"6. From 1660 to 1680, thus lasting for twenty-one years; interval to next period, sixty-six years.

"7. From 1747 to 1808, thus lasting for sixty-two years; interval to next period, sixty-eight years.

"8. From November, 1877, to February, 1878.

"The most important period was the above No. 7, especially during the last twenty years of the last century. It has been calculated that in some years during that time the annual quantity of Herring fished in Bohuslan amounted to at least 1,500,000 barrels.

"During the six weeks January 1 to February 15, this present year, about 160,000 barrels of fresh and salt Herring were shipped from the archipelago of Bohuslan to neighboring markets. The fishermen and merchants are preparing largely for making big hauls when the Herring will return in the fall, as is expected."

As early as the middle of the last century one of the periods of scarcity was foretold by Prof. Hans Ström, of Norway, who observed that the Herrings during the period they visited the coast of Sondmor (1736–1756) came later and later every year, and predicted, in accordance with an old tradition and the experience had at Stät, that the Herring fisheries of Sondmor would come to an end. This really took place in Bohuslan, where it had been observed already towards the middle of the last great fishery period that the Herrings came to the coast later and later every year, which led people to fear that, as in times of old, the Herrings might again gradually leave the Swedish coast. Somewhat later (1782) Ström compared the Bohuslan fisheries with those of Norway, and, basing his opinion on their evident similarity, predicted that the end of the Bohuslan fisheries was near at hand.

About ten years later Lybecker expresses himself more distinctly, as follows: "If with prophetic eye we could see the future and predict the fate of the fisheries, we might say with a great degree of probability that a change will take place soon. We know from history that when Herrings or other fish of passage arrive near the coast later and later, and at the same time keep farther and farther away from the coast, this means a change in the migrations of the Herrings, and may even point to their leaving the coast entirely. This has been the course of the Norwegian herring fisheries, and even of the Swedish herring fisheries during their older periods, and in fact with all those fisheries where fish of passage are the principal object, with the only exception of the Scotch and English fisheries. . . . If we take into consideration the roving nature of the Herrings and the examples from olden times, it is highly probable that the Herrings will come later every year, and finally leave our coast altogether."

It had frequently been maintained that too much fishing and fishing with destructive apparatus were the proper causes of the growing tardiness of the arrival of the Herrings and might even lead to the complete cessation of the fisheries; and people therefore made futile attempts to obviate this danger by legislation. As the ominous predictions regarding the herring fisheries were, however, not immediately fulfilled, they were almost forgotten; but when the herring fisheries came to an end in the year 1808, people imagined that the Herrings arriving later and later every year fully proved the assertion that they had been driven away by the imprudent actions of the fishermen. It was said that refuse thrown into the water, and noise, had prevented the Herrings from coming near to the coast, and they had spawned in the open sea, and had then, in consequence of the languor and weakness following the spawning, been driven towards the coast by storms.

During the more recently closed Norwegian spring herring fisheries, it was, according to Loberg, noticed, not without anxious forebodings, that the Herrings, which in the beginning of the fishing period did not come near the coast till early in February, gradually came earlier and

earlier, so that finally the fisheries commenced before New Years; and that this change was followed by another, the Herrings coming later and later, till the fisheries did not commence before February. This peculiarity, however, was thought to be a consequence of the irregularity with which the Herrings visited the same places on the coast. It was not till Axel Boeck began to investigate the matter that this whole question was treated from a more scientific standpoint. He showed that the coming of the herrings to the coast at different times during the period was subject to certain rules, and that this regularity in the movements of the Herrings was observed not only during the Norwegian spring herring fisheries of the seventeenth and eighteenth centuries, but also during those herring fisheries which were going on on the coast of Bohuslan during the second half of the fifteenth and seventeenth centuries. This peculiar phenomenon has therefore become far more important than it was thought to be in former times; and it may well be said to contain the key to the question of the periodicity of the great Scandinavian herring fisheries. Boeck was not able to assign any cause for these entirely regular changes in the time of the Herrings' visits to the coast. This has been attempted, however, by G. O. Sars and myself, and an account of these attempts will be given below.

In a paper entitled "The Great Bohuslan Herring Fishery,"[1] A. N. Ljungman gives a very interesting account of the periods of abundance of Herring in Sweden and of the herring fisheries of that region from 1000 A. D. to the present date.

REPRODUCTION.—There are several interesting series of observations upon the spawning habits of the Herring, the hatching of the egg, and the development of the young; all of which may be found in the later volumes of the Report of the United States Commissioner of Fisheries.

In his lecture on the Herring, Professor Huxley describes in a very concise and lucid way their spawning habits. He remarks: "We have hitherto met with no case of full or spawning Herrings being found, in any locality, during what may be termed the solstitial months, namely, June and December; and it would appear that such Herrings are never (or very rarely) taken in May, or the early part of July, in the latter part of November, or the early part of January. But a spring spawning certainly occurs in the latter part of January, in February, in March, and in April; and an autumn spawning in the latter part of July, in August, September, October, and even as late as November. Taking all parts of the British coast together, February and March are the great months for the spring spawning, and August and September for the autumn spawning. It is not at all likely that the same fish spawn twice in the year; on the contrary, the spring and the autumn shoals are probably perfectly distinct; and if the Herring, according to the hypothesis advanced above, come to maturity in a year, the shoals of each spawning season would be the fry of the twelvemonth before. However, no direct evidence can be adduced in favor of this supposition, and it would be extremely difficult to obtain such evidence.

"I believe that these conclusions, confirmatory of those of previous careful observers, are fully supported by all the evidence which has been collected; and the fact that this species of fish has two spawning seasons, one in the hottest and one in the coldest month of the year, is very curious.

"Another singular circumstance with the spawning of the Herring is the great variety of the conditions, apart from temperature, to which the fish adapts itself in performing this function. On our own coast, Herrings spawn in water of from ten to twenty fathoms, and even at greater depths, and in a sea of full oceanic saltness. Nevertheless, Herrings spawn just as freely not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water

[1] A translation of which is published in United States Fish Commission Report, part vi; pp. 221–239.

of which is quite drinkable and is inhabited by fresh-water fish. Here the Herrings deposit their eggs in two or three feet of water; and they are found, along with the eggs of fresh-water fish, sticking in abundance to such fresh-water plants as *Potamogeton*.

"Nature seems thus to offer us a hint as to the way in which a fish like the shad, which is so closely allied to the Herring, has acquired the habit of ascending rivers to deposit its eggs in purely fresh water.

"If a full female Herring is gently squeezed over a vessel of sea-water, the eggs will rapidly pour out and sink to the bottom, to which they immediately adhere with so much tenacity that, in half an hour, the vessel may be inverted without their dropping out. When spawning takes place naturally, the eggs fall to the bottom and attach themselves in a similar fashion, but at this time the assembled fish dart wildly about, and the water becomes cloudy with the shed fluid of the milt. The eggs become thus fecundated as they fall, and the development of the young within the ova sticking to the bottom commences at once.

"The first definite and conclusive evidence as to the manner in which herring-spawn is attached and becomes developed that I know of was obtained by Professor Allman and Dr. Macbain in 1862, in the Frith of Forth. By dredging in localities in which spent Herring were observed on the 1st of March, Professor Allman brought up spawn in abundance at a depth of fourteen to twenty-one fathoms. It was deposited on the surface of the stone, shingle, and gravel, and on old shells and coarse shell-sand, and even on the shells of small living crabs and other crustacea, adhering tenaciously to whatever it had fallen on. No spawn was found in any other part of the Forth; but it continued to be abundant on both the east and the west sides of the Isle of May up to the 13th of March, at which time the incubation of the ovum was found to be completed in a great portion of the spawn, and the embryos had become free. On the 25th scarcely a trace of spawn could be detected, and nearly the whole of the adult fish had left the Forth.

"Professor Allman draws attention to the fact that 'the deposit of spawn, as evidenced by the appearance of spent Herrings, did not take place till about sixty-five days after the appearance of the Herring in the Frith,' and arrives at the conclusion that 'the incubation probably continues during a period of between twenty-five to thirty days,' adding, however, that the estimate must, for the present, be regarded as only approximative. It was on this and other evidence that we based our conclusion that the eggs of the Herring 'are hatched in at most from two to three weeks after deposition.'

"Within the last few years a clear light has been thrown upon this question by the labors of the West Baltic Fishery Commission, to which I have so often had occasion to refer. It has been found that artificial fecundation is easily practiced, and that the young fish may be kept in aquaria for as long as five months. Thus a great body of accurate information, some of it of a very unexpected character, has been obtained respecting the development of the eggs and the early condition of the young Herring.

"It turns out that, as is the case with other fishes, the period of incubation is closely dependent upon warmth. When the water has a temperature of 53° F. the eggs of the Herring hatch in from six to eight days, the average being seven days. And this is a very interesting fact when we bear in mind the conclusion to which the inquiries of the Dutch meteorologists, and, more lately, those of the Scottish Meteorological Society, appear to tend, namely, that the shoals prefer water of about 55° F. At 50° F. the period of incubation is lengthened to eleven days; at 46° F. to fifteen days; at 38° F. it lasts forty days. As the Forth is usually tolerably cool in the month of March, it is probable that Professor Allman's estimate comes very near the truth for the particular case which he investigated.

"The young, when they emerge from the egg, are from one-fifth to one-third of an inch in length, and so extremely unlike the adult Herring that they may properly be termed 'larvæ.' They have enormous eyes and an exceedingly slender body, with a yelk-bag protruding from its fore part. The skeleton is in a very rudimentary condition; there are no ventral fins; and, instead of separate dorsal, caudal, and anal fins, there is one continuous fin, extending from the head along the back, round the tail, and then forward to the yelk-bag. The intestine is a simple tube, ciliated internally; there is no air-bladder, and no branchiæ are yet developed. The heart is a mere contractile vessel, and the blood is a clear fluid without corpuscles. At first the larvæ do not feed, but merely grow at the expense of the yelk, which gradually diminishes.

"Within three or four days after hatching, the length has increased by about half the original dimensions, the yelk has disappeared, the cartilaginous skeleton appears, and the heart becomes divided into its chambers; but the young fish attains nearly double its first length before blood-corpuscles are visible.

"By the time the larva is two-thirds of an inch long (a length which it attains one month after hatching), the primitive median fin is separated into dorsal, caudal, and anal divisions, but the ventral fins have not appeared. About this period the young animal begins to feed on small crustacea; and it grows so rapidly that at two months it is one and a quarter inches long, and at three months has attained a length of about two inches.

"Nearly up to this stage the elongated, scaleless little fish retains its larval proportions; but in the latter part of the third month the body rapidly deepens, the scales begin to appear, and the larva passes into the 'imago' state, that is, assumes the forms and proportions of the adult, though it is not more than two inches long. After this, it goes on growing at the same rate (eleven millimeters, or nearly half an inch) per month, so that at six months old it is as large as a moderate-sized sprat.

"The well-known 'Whitebait' of the Thames consists, so far as I have seen, almost exclusively of Herrings under six months old, and as the average size of Whitebait increases from March and April onward until they become suspiciously like sprats in the late summer, it may be concluded that they are the progeny of Herrings which spawned early in the year in the neighborhood of the estuary of the Thames, up which these dainty little fish have wandered. Whether it is the general habit of young Herring, even of those which are spawned in deep water, to migrate into the shallow parts of the sea, or even into completely fresh waters, when such are accessible, is unknown.

"In the 'Report on Trawling' (1863) we observe: 'It is extremely difficult to obtain any satisfactory evidence as to the length of time which the Herring requires to pass from the embryonic to the adult or full condition. Of the fishermen who gave any opinion on this subject, some considered that a Herring takes three, and others that it requires seven, years to attain the full or spawning condition; others frankly admitted that they knew nothing about the matter; and it was not difficult, by a little cross-examination, to satisfy ourselves that they were all really in this condition, however strongly they might hold by their triennial or septennial theories. Mr. Yarrell and Mr. Mitchill suppose with more reason that Herring attain to full size and maturity in about eighteen months. It does not appear, however, that there is any good evidence against the supposition that the Herring reaches its spawning condition in one year. There is much reason to believe that the eggs are hatched in, at most, from two to three weeks after deposition, and that in six to seven weeks more (that is, at most, ten weeks from the time of laying the eggs) the young have attained three inches in length. Now, it has been ascertained that a young smolt may leave a river and return to it again in a couple of months increased in bulk eight or ten fold, and as a

Herring lives on very much the same food as a smolt, it appears possible that it should increase in the same rapid ratio. Under these circumstances nine months would be ample time for it to enlarge from three to ten or eleven inches in length. It may be fairly argued, however, that it is not very safe to reason analogically from the rate of growth of one species of fish to that of another; and it may be well to leave the question whether the Herring attains its maturity in twelve, fifteen, or sixteen months open, in the tolerably firm assurance that the period last named is the maximum.'

"On comparing these conclusions with the results of the careful observations of the Baltic commissioners, it appears that we somewhat overestimated the rate of growth of the young Herring, and that the view taken by Yarrell and Mitchill is more nearly correct. For, supposing that the rate of growth after six months continues the same as before, a Herring twelve months old will be nearly six inches long, and at eighteen months eight or nine inches. But full Herrings may be met with little more than seven inches long, and they are very commonly found not more than nine inches in length.

"Herrings which have attained maturity, and are distended by the greatly enlarged milt or roe, are ready to shed the contents of these organs, or, as it is said, to spawn. In 1862 we found a great diversity of opinion prevailed as to the time at which this operation takes place, and we took a great deal of trouble to settle the question, with the result which is thus stated in our report: 'We have obtained a very large body of valuable evidence on this subject, derived partly from the examination of fishermen and of others conversant with the herring fishery; partly from the inspection of the accurate records kept by the fishery officers at different stations, and partly from other sources; and our clear conclusion from all this evidence is, that the Herring spawns at two seasons of the year, in the spring and in the autumn.'

"The milt and roe are elongated organs attached beneath the air-bladder, which lie one on each side of the abdominal cavity, and open behind the vent by an aperture common to the two. The spermatic fluid of the male is developed in the milt and the eggs of the female in the roe. These eggs, when fully formed, measure from one-sixteenth to one twenty-fifth of an inch in diameter; and as, in the ripe female, the two roes or ovaries stretch from one end of the abdominal cavity to the other, occupying all the space left by the other organs, and distending the cavity, the number of eggs which they contain must be very great; probably ten thousand is an underestimate of the number of ripe eggs shed in spawning by a moderate-sized female Herring. But I think it is safer than the thirty thousand of some estimates, which appear to me to be made in forgetfulness of the very simple anatomical considerations that the roe consists of an extensive vascular framework as well as of eggs; and, moreover, that a vast number of the eggs which it contains remain immature and are not shed at the time of spawning."[1]

Professor Baird, in 1877, wrote as follows concerning the spawning habits of the Herring on our own coast:

"In the Bay of Saint Lawrence they appear to spawn in the spring, especially in the vicinity of the Magdalen Islands, the fishes there taken being ripe with eggs. At that time they come so close to the land as to permit their capture in immense numbers in seines. It is also thought that a so called school spawns in the spring in the Bay of Fundy, from the head to the mouth. Such a spawning ground is believed to exist in the Bay of Saint Andrew's, and in certain portions of

[1] The observations of Mr. Earll at Eastport indicate that in his opinion none of the Herrings used in the sardine factories are old enough to show any traces of developing spawn, although there can be no doubt that they are not less than a year old. The fish upon which his observations were made were taken in September, and must have been hatched as early as the September of the preceding year.

Passamaquoddy Bay. One principal spawning ground of the Herring in the Bay of Fundy, is near the southern head of Grand Menan; and by a very wise provision of the New Brunswick Government, a close time was many years ago enacted, extending from the 15th of June to the 15th of September, during which the capture of these fish was forbidden. They now resort to that portion of the coast in considerable numbers, and the quantity of eggs deposited is said to be something almost inconceivable.

"The spawning season, too, appears to be later and later as we proceed westward from Maine. Thus, allowing it to be at its height there in the beginning of August,[1] it occurs in September off the coast of Maine, and in October off Eastern Massachusetts; in November at Cape Cod, and in December at Noman's Land and Block Island; possibly still later farther south.

"The eggs are minute, less in size than those of the shad, and adhere when discharged to rocks, seaweed, etc., being scattered singly or in bunches over a vast extent of sea bottom. I have frequently brought them up at various depths and at a considerable distance from the shore, off Grand Menan."[2]

ARTIFICIAL PROPAGATION OF THE HERRING.—In the spring of 1878 the first successful experiments in the artificial propagation of Herring were carried on in Germany by Dr. H. A. Meyer, of the Commission for Scientific Investigation of the German Seas at Kiel, and in the fall of the same year by Mr. R. E. Earll, of the United States Fish Commission, at Gloucester. A translation of Dr. Meyer's paper may be found in part vi, United States Fish Commission Report, pp. 629–638, and a brief summation of Mr. Earll's experiments in the same volume, pp. 727–729.

FOOD.—Much has been written upon the food of the Herring, but the following translation from an article in "Die Natur," No. 47, 1869, gives in a very satisfactory manner recent views of European authorities upon the subject:

"Of the various fishes that inhabit the waters, few have, perhaps, more direct bearing upon the prosperity of the maritime people of the north than the sea Herring; the shores of both hemispheres being visited regularly by countless myriads that furnish an inexhaustible source of food. It is, therefore, not to be wondered at that the attention of fishermen, as well as statesmen and political economists, has been directed to the different questions connected with the migrations and preservation of these fish, and that much research should have been expended in determining various points connected with their history. Until quite

[1] A large school of Herrings appears annually in the vicinity of Boisbobert Island, in Eastern Maine, off Millbridge, where they spawn on the rocky bottom.—R. E. EARLL.

[2] A visit in 1872 to the Southern Head of Grand Menan, during the spawning season of the Herring, enabled my assistant, Dr. Palmer, to obtain a very interesting series of eggs and young by using the dredge, the eggs being found at low water, from near the shore, out to a distance of several miles.

Over an extended area, whenever any gravel, stones, or sea-weed were brought up with the dredge they were found to be thickly dotted over with these eggs, sometimes single, at others in clusters.

It would appear that in the operation of exclusion, the eggs fall away into the water in masses varying in size, although in no instance was the entire spawning of any one fish observed in a single mass. The largest aggregations consisted of masses of the size of a hazel-nut. Sometimes these heat up and separate entirely. The eggs were very minute, not larger than No. 7 shot, and when taken up nearly all the eggs contained embryos, of which the eyes were very large and distinct. The eggs appear to sink to the bottom if not laid there originally, and to adhere at once to adjacent objects. A careful straining of the surface-water and down to a considerable depth with the towing-net, or hand gauge-net, brought up no floating eggs.

A large number of eggs were brought over to Eastport in salt water and a considerable number of these hatched out on the way, during an interval of a few hours, and many others became developed soon after they were brought ashore. All the embryos had left their envelopes by the next morning. The young could be distinctly seen inside of the egg, and when this was ruptured they were extremely active in their movements through the water, springing up and down and crosswise, wriggling precisely like the larvæ of a dipterous insect. Their length at this time was about thirty one-hundredths of an inch, some few being larger and others rather smaller.

recently, however, one important element of their biography has been unsolved, namely, the precise nature of the food upon which they subsist, at least during the time when they come into the vicinity of the shore, although their varying degree of excellence throughout the year is believed to depend largely upon what they find to eat in the different months.

"Intimately connected with this same subject of the food of the Herring is the fact that at times it is found almost impossible to preserve the fish after being caught, since, notwithstanding the prompt use of salt, decomposition ensues and spoils the entire catch. Indeed, at certain seasons of the year, it is said that Herrings cannot be preserved at all except by taking the precaution of retaining them alive in the net for a period of from three to ten days.

"A very important communication on the food of the Herring has lately been published by a Danish author, Mr. Axel Boeck, from which we learn that the herring food, or 'meat,' consisting almost entirely of minute invertebrate animals, is divided by the northern fishermen into three classes; the 'red,' the 'yellow,' and the 'black,' the names being derived from the color of this food when living, or else from its appearance when in the fish's stomach. The red meat (*Rödaat*) is the most common and best known, and occurs along the entire coast of Norway and in the mouths of the bays (but more sparingly in the bays themselves), and in the open sea, diminishing in amount, apparently, with the depth. At certain periods of summer, however, it appears in such immense abundance that the sea is colored red by it. When floating in this way upon the surface, it attracts innumerable schools of mackerel, as well as of Herrings, which are then much less shy than usual, and the scene is one of impressive activity, owing to the number of boats and nets employed in fishing. On a careful examination this substance was found to consist almost entirely of small crustaceans, Copepod, the largest, scarcely the thirtieth of an inch in length and barely distinguishable by the naked eye.

"It can hardly be believed that such minute and almost microscopic animals can be of so much importance to the welfare of a nation; but in reality the mackerel and the autumnal Herrings owe their fatness to them, the microscope revealing through their thin shells the fat lying in distinct strips between the muscles and intestines.

"These same crustaceans occur also off Spitzbergen in such abundance as to furnish food to innumerable water fowl; and even the whales feed upon them to a great extent.

"If, now, the Herring has taken in a large quantity of this 'red food,' and is then captured and killed without its having been fully digested, the animal matter in the stomach of the fish begins to spoil before it can be reached by the salt, and the stomach thus becomes putrid, as well as the large bloodvessel which lies under the back, the coloring matter of the blood imparting a reddish tinge to the flesh alongthe backbone. For this reason it is required by law to keep Herrings three days in the nets, in order that all the contents of the stomach may be completely digested, while the fish is prevented from taking in a fresh supply. Sometimes, however, the winds drift this herring food into the nets, and furnish to the Herrings an opportunity, which they eagerly embrace, rendering them again liable to the difficulty just mentioned.

"When a Herring, on being squeezed, discharges a yellow pulp, this is known as 'yellow meat,' or *Gulaat*. This is not so abundant as the other, but appears, like the 'red meat,' to be composed in part of transparent Copepods, together with the larvæ of tapeworms and other annelids which occur on the Norwegian coast in immense numbers. It is stated that the surface of the sea is sometimes seen to be completely covered with little worms of about the twenty-fourth of an inch in length, swimming actively about by means of certain hairs which encircle their bodies like a girdle. These animals were sufficiently developed to permit their

identification as the young of *Leucodore ciliata*. Herring and mackerel feed largely upon these animals, so that the 'yellow meat' consists in greater part of the fine hairs which cover the exterior of the larvæ in question. This kind of food is considered to interfere less with the proper curing of the Herring, as it is much more quickly digested.

"The most objectionable kind of herring food, however, is that which is known as the 'black meat,' or *Svartaat*, sometimes called *Krutaat*, and occurring on the surface of the sea in the form of little granules moving freely about, but which sink on being touched. This is said to be most abundant in rainy seasons when there is a short interval of fine and clear weather. Herring that have fed on this substance are considered to be entirely unfit for salting, even when kept in the nets for a much longer time than that already mentioned. The salted fish has an extremely disagreeable smell, even after the stomach with its contents has been removed. A microscopic examination of this matter showed that it consists entirely of the larval young of small shells found among the sea-weed and belonging to the genus *Rissoa*. These swim by means of two flippers, covered with hairs, which are protruded from a transparent shell having from three to seven turns or windings. They are about one-tenth of an inch in length, and on being touched draw within the shell and sink to the bottom. When full grown, these mollusks lose their flippers and creep about the sea-weed by means of a large foot. Thus, it is easy to understand why this 'black meat' is more dangerous than the other kinds. While the shells of the animals forming the 'red meat' are quite thin and the bodies of the 'yellow meat' are very soft, those of the 'black meat,' on the contrary, being inclosed in hard shells, are not so readily reached by the digestive fluid, so that while the exterior parts, namely, the swimming flippers, are quickly digested the rest of the body within the shell becomes decomposed. On this account the flesh of the Herring after feeding upon these mollusks soon becomes tainted by their decomposition and gives out a disagreeable smell, notwithstanding the application of salt.

"It may be asked why the summer and autumnal Herrings feed upon this food and not the spring Herring, nor those taken in the open sea, both the latter being capable of preservation without any detention in the nets. The reason of this seems to be that the spring and open-sea Herrings are captured when under the stimulus of the spawning season and in the search for a suitable place for the development of their young. At this time the question of food is reduced to zero or near it, and a careful examination of the stomachs of Herrings taken under such circumstances shows comparatively little animal matter. Summer and autumn Herrings, on the other hand, are specially engaged in seeking for food and bringing up their flesh, and that at a time when the larvæ of the lower animals are found swimming freely about in large quantity upon the surface of the sea."[1]

CAPTURE AND USES.—The methods of capture of the Herring are fully described in the chapter by Mr. Earll upon the herring fisheries of the United States (to be printed in a subsequent portion of this report).

"It is not a little remarkable," writes Professor Baird, "that while with most fish the spawning

[1] Professor Möbius found that almost the sole food of the Herring taken in Kiel Bay, in the winter and spring of 1872, when they were captured in immense quantities, consisted of a minute crustaceous animal, nearly allied to the common fresh-water cyclops, and but little larger. The apparatus, which enables the Herring to feed on these minute creatures, is described by Professor Möbius as a sort of basket or "lobster-pot," formed by the arches of the gills, each of which is furnished with a close-set fringe of teeth, while each of the latter bears two rows of minute spines. The interlacing of these teeth and spines produces a narrow lattice-work, through which the water can readily pass, while the little swimming animals contained in it are left behind in the mouth of the fish and gradually pass down into its stomach. Some notion of the number of little crustaceans consumed by the Herring may be formed from the fact that Professor Möbius reckons 10,000 as the average number to be found in a Herring's stomach, and in one instance no fewer than 61,000 were found. The sprat, the mackerel, and some other fishes, are provided with an apparatus more or less resembling that of the Herring.—*Annals of Natural History*.

season is considered an undesirable period for their capture, with the *Clupeidæ*, such as the shad, the alewife, and the sea Herring, they are then thought to be in the greatest perfection; indeed, females, full of partially developed eggs, are esteemed a great delicacy, both in regard to the fish and the roe. Nearly all the European fisheries, especially those on the coast of Scotland, are carried on when the fish is in full roe, when the taking of fish is considered very prejudicial to the perpetuation of the species. The number taken, however, does not appear to affect the abundance of the Herring, and, indeed, with the enormous yield of eggs, a very small percentage of adults will keep up the supply.

"There appears to be as much uncertainty in Europe as there is in this country in regard to the exact period of the growth of the Herring, Ljungman[1] remarking that the spring Herring spawned in March attain a length of two and a half to three and a half inches by the end of the year, and that in the following May, or at the age of one year, their average length is four inches. He states that the two-year-old fish range from five and a half to six inches in length, and that those of three years are six or seven inches long, having the sexual apparatus complete but not highly developed. The eight-inch fish are four years old, while those larger are of still greater age."

In Europe the ways in which Herrings are prepared for use as food are very numerous and varied, there being many ways of salting them, many ways of smoking them, and many ways of preserving them in spices. The day is probably not distant when Europe will follow the example of the United States and employ them extensively in the manufacture of sardines. The European fishery reports are full of codes of instruction for preparing the different grades of Herrings for exportation and local consumption; but, as a rule, these preparations are not congenial to the American palate, and need not here be particularly described. Our supply of other excellent food fishes is so great that but little attention is paid by American fishermen to the capture of Herrings for food. Many cargoes of frozen Herrings are brought from Newfoundland and the Bay of Fundy to Boston, New York, and Philadelphia to serve for the food of the poorer classes during the Lenten season. A limited quantity of pickled Herrings is also imported from the British Provinces. Smoked Herrings are produced to the amount of 370,615 boxes in Eastern Maine, and large quantities are imported from New Brunswick and Nova Scotia, which are sent chiefly to the West and South, though small quantities are consumed in the rural districts of New England. Before the rebellion Eastern Maine engaged largely in herring-smoking for the purpose of supplying the demand of the slave-owning States, and many cargoes of fish slightly pickled for smoking were brought from the Magdalen Islands. This business was broken up by the war, and most of the smoke-houses remain abandoned to this day. Considerable quantities of smoked Herrings are now put up in small packages with skin and bones removed, under the trade name of "boneless Herring." By far the greatest consumption of Herrings for food is in the shape of so-called sardines, packed for the most part in cotton-seed oil, and in cans made in imitation of those imported from France. This industry began in 1875 and increased yearly until 1880, when the production amounted to 2,377,152 one-pound cans, worth $772,176.

Fresh Herrings and salted Herrings are used extensively for bait in the halibut and cod fisheries, and a special night fishery with torches for young Herrings, or Sperling, is carried on in the fall months about Cape Ann, Massachusetts, for the supply of the shore fishermen.

THE ALLEGED DESTRUCTIVENESS OF THE HERRING FISHERY.—As has already been remarked, the Herring fishery is not at present of sufficient importance upon our coast to have provoked the protection of the law, although the only place in the world where the spawning Herrings are protected by the law is at the southern end of Grand Manan, within twenty-five miles

[1] United States Fish Commission Report, p. 144.

from the western boundary of the United States. The question of the protection of the Herring is not likely soon to come up in our legislatures. It has, however, for many years been deeply agitated in Europe, and in Great Britain especially has occupied the attention of learned commissions for periods extending over many months. In 1862 and 1865 special commissions were engaged in the investigation of the influence of the trawl-net fishery, particularly with reference to its connection with the herring fishery. And it is a matter of considergble interest to be able to quote in a few paragraphs the conclusions reached by Professor Huxley, who was a member of each of these commissions, not because, as already suggested, the question of protecting the herring fishery is likely to be agitated in the United States, but because the same class of facts and the same train of reasoning will apply with almost equal force to the problem of the protection of the mackerel, menhaden, and other similar fisheries. He spoke as follows in 1881 in the lecture already referred to:

"I do not believe that all the herring fleets taken together destroy five per cent. of the total number of Herrings in the sea in any year, and I see no reason to swerve from the conviction my colleagues and I expressed in our report, that their destructive operations are totally insignificant when compared with those which, as a simple calculation shows, must regularly and normally go on.

"Suppose that every mature female Herring lays 10,000 eggs, that the fish are not interfered with by man, and that their numbers remain approximately the same year after year, it follows that 0,998 of the progeny of every female must be destroyed before they reach maturity. For, if more than two out of the 10,000 escape destruction, the number of Herrings will be proportionately increased. Or, in other words, if the average strength of the shoals which visit a given locality is to remain the same year by year, many thousand times the number contained in those shoals must be annually destroyed. And how this enormous amount of destruction is effected will be obvious to any one who considers the operations of the fin-whales, the porpoises, the gannets, the gulls, the codfish, and the dog-fish, which accompany the shoals and perennially feast upon them; to say nothing of the flat-fish, which prey upon the newly-deposited spawn; or of the mackerel and the innumerable smaller enemies which devour the fry in all stages of their development. It is no uncommon thing to find five or six—nay, even ten or twelve—Herrings in the stomach of a codfish, and in 1863 we calculated that the whole take of the great Scotch herring fisheries is less than the number of Herrings which would in all probability have been consumed by the codfish captured in the same waters if they had been left in the sea. Man, in fact, is but one of a vast co-operative society of herring catchers, and the larger the share he takes the less there is for the rest of the company. If man took none, the other shareholders would have a larger dividend, and would thrive and multiply in proportion, but it would come to pretty much the same thing to the Herrings.

"As long as the records of history give us information, Herrings appear to have abounded on the east coast of the British Islands, and there is nothing to show, so far as I am aware, that, taking an average of years, they were ever either more or less numerous than they are at present. But, in remarkable contrast with this constancy, the shoals of Herrings have elsewhere exhibited a strange capriciousness—visiting a given locality for many years in great numbers, and then suddenly disappearing. Several well marked examples of this fickleness are recorded on the west coast of Scotland; but the most remarkable is that furnished by the fisheries of Bohuslan, a province which lies on the southwestern shore of the Scandinavian Peninsula. Here a variety known as the 'old' or 'great' Herring, after being so extremely abundant, for about sixty years,

as to give rise to a great industry, disappeared in the year 1808, as suddenly as they made their appearance, and have not since been seen in any number.

"The desertion of their ordinary grounds by the Herring has been attributed to all imaginable causes, from fishing on a Sunday to the offense caused to the fish by the decomposing carcasses of their brethren, dropped upon the bottom out of the nets. The truth is, that absolutely nothing is known on the subject, and that little is likely to be known until careful and long-continued *meteorological and zoological observations have furnished definite information respecting the* changes which take place in the temperature of the sea, and the distribution of the pelagic crustacea which constitute the chief food of the herring shoals. The institution of systematic observations of this kind is an object of international importance, toward the attainment of which the British, Scandinavian, Dutch, and French Governments might wisely make a combined effort.

"A great fuss has been made about trawlers working over the spawning grounds of the Herring. 'It stands to reason,' we were told, 'that they must destroy an immense quantity of the spawn.' Indeed, this looked so reasonable that we inquired very particularly into a case of the alleged malpractice which was complained of on the east coast of Scotland, near Pittenweem. Off this place there is a famous spawning ground known as the Traith Hole, and we were told that the trawlers worked vigorously over the spot immediately after the Herring had deposited their spawn. Of course our first proceeding was to ask the trawlers why they took the trouble of doing what looked like wanton mischief. And their answer was reasonable enough. It was to catch the prodigious abundance of flat-fish which were to be found on the Traith at that time. Well, then, why did the flat-fish congregate there? Simply to feed on herring eggs, which seem to be a sort of flat-fishes' caviare. The stomachs of the flat-fish brought up by the trawl were, in fact, crammed with masses of herring eggs. Thus every flat-fish caught by the trawl was an energetic destroyer of Herring arrested in his career. And the trawling, instead of injuring the Herring, captured and removed hosts of their worst enemies. That is how 'it stood to reason' when one got to the bottom of the matter.

"I do not think that any one who looks carefully into the subject will arrive at any other conclusion than that reached by my colleagues and myself, namely, that the best thing for governments to do in relation to the herring fisheries is, to let them alone, except in so far as the police of the sea is concerned. With this proviso, let people fish how they like, as they like, and when they like. At present, I must repeat the conviction we expressed so many years ago, that there is not a particle of evidence that anything man does has an appreciable influence on the stock of Herrings. It will be time to meddle when any satisfactory evidence that mischief is being done is produced."

173. THE HERRINGS OF THE PACIFIC COAST.

THE CALIFORNIA HERRING—CLUPEA MIRABILIS.

"This species," writes Professor Jordan, "is universally known as the Herring. It indeed scarcely differs in size, appearance, or qualities from the Herring of the Atlantic. It reaches a length of about a foot. It is found for the entire length of the coast, being exceedingly abundant northward. All the bay sand outlets of Puget Sound are filled with them in the summer. South of Point Concepcion they are seldom seen except in winter. At San Diego they spawn in the bay in January. Farther north their spawning season comes later. They are so abundant in San Francisco Bay in the spring that eighty pounds can often be bought for twenty cents. They are fattest and bring the best price in early winter. The Herrings are smoked and dried, or salted, or

sent fresh to the markets. Sometimes herring oil is expressed from them. The principal herring-curing establishment is at Port Madison, on Puget Sound."

THE CALIFORNIA SARDINE—CLUPEA SAGAX.

"This species," writes Professor Jordan, "is everywhere known as the Sardine, or by the Italians as 'Sardina.' It is, in fact, almost exactly identical with the Sardine of Europe. It reaches a length of a little less than a foot. It ranges from Cape Mendocino to Chili, and is extremely abundant southward, especially in the winter, when it fills all the bays. In the summer it is generally scarce southward, although still taken northward. The young are, however, seen in San Diego in the summer. It is probably to some extent migratory along the coast, but as little attention is paid to it, no definite data can be given. It is brought into the markets when taken, and is sold with the Herring. The question of the possibility of canning it in oil, like the Sardine, has been considerably discussed. It would probably prove unprofitable, from the high price of labor and the uncertain supply of fish."

174. THE MENHADEN—BREVOORTIA TYRANNUS.[1]

NAMES.—The Menhaden has at least thirty popular names, most of them limited in their use within narrow geographical boundaries. To this circumstance may be attributed the prevailing ignorance regarding its habits and migrations, among our fishermen, which has perhaps prevented the more extensive utilization of this fish, particularly in the South.

North of Cape Cod the name "Pogy" is almost universally in use, while in Southern New England the fish is known only as the "Menhaden." These two names are derived from two Indian words of the same meaning; the first being the Abnaki name "Pookagan," or "Poghaden," which means "fertilizer," while the latter is the modification of a word which in the Narragansett dialect meant "that which enriches the earth." About Cape Ann, "Pogy" is partially replaced by "Hard-head," or "Hard-head Shad," and in Eastern Connecticut by "Bony Fish." In Western Connecticut the species is usually known as the "White-fish," while in New York the usage of two centuries is in favor of "Mossbunker." This name is a relic of the Dutch colony of New Amsterdam, having evidently been transferred from the "Scad," or "Horse Mackerel," *Trachurus lacerta*, a fish which visits the shores of Northern Europe in immense schools, swimming at the surface in much the same manner as our Menhaden, and known to the Hollanders as the "Marshbanker." New Jersey uses the New York name with its local variations, such as "Bunker" and "Marshbanker." In Delaware Bay, the Potomac, and the Chesapeake, we meet with the "Alewife," "Bay Alewife," "Pilcher" (Pilchard), and "Green-tail." Virginia gives us "Bug-fish," "Bug-head," and "Bug-shad," referring to the parasitic crustacean found in the mouths of all Southern Menhaden. In North Carolina occurs the name "Fat-back," which prevails as far south as Florida, and refers to the oiliness of the flesh. In this vicinity, too, the names "Yellow-tail" and "Yellow-tailed Shad" are occasionally heard, while in Southern Florida the fish is called "Shiner" and "Herring." In South America, among the Portuguese, the name "Savega" is in use. On the Saint John's River, and wherever northern fishermen are found, "Menhaden" is preferred, and it is to be hoped that this name will in time be generally adopted. A number of trade names are employed by the manufacturers in New Jersey who can this fish for food; these are "American Sardine," "American Club-fish," "Shadine," and "Ocean Trout."

In 1815 the species was described by Mitchill, of New York, under the name *Clupea menhaden*,

[1] For a fuller account of this fish, see an elaborate memoir in part v of the Report of the Commissioner of Fisheries.

which has since been constantly accepted. A prior description by Latrobe, in 1802, long lost sight of, renders it necessary, as I have elsewhere demonstrated, to adopt the specific name *tyrannus*. The genus *Brevoortia*, of which this species is the type, was established by Gill in 1861.

DISTRIBUTION.—The geographical range of *Brevoortia tyrannus* varies from year to year. In 1877 it was, so far as it is definable in words, as follows: The wanderings of the species are bounded by the parallels of north latitude 25° and 45°; on the continental side by the line of brackish water; on the east by the inner boundary of the Gulf Stream. In the summer it occurs in the coastal waters of all the Atlantic States from Maine to Florida, in winter only south of Cape Hatteras. The limits of its winter migration oceanward cannot be defined, though it is demonstrated that the species does not occur about the Bermudas or Cuba, nor presumably in the Caribbean Sea. In Brazilian waters occurs a geographical race of the same species, *Brevoortia tyrannus*, subspecies *aurea* (the *Clupanodon aureus* of Agassiz and Spix); on the coast of Paraguay and Patagonia by *Brevoortia pectinata*; in the Gulf of Mexico by *Brevoortia patronus*.

MOVEMENTS.—With the advance of spring Menhaden appear near our coasts in company with, and usually slightly in advance of, the other more resident species, such as the Shad, Alewife, Bluefish, and Squeteague. The following general conclusions regarding their movements are deduced from the statements of about two hundred observers at different points on the coasts from Florida to Nova Scotia.

At the approach of settled warm weather they make their appearance in the inshore waters. It is manifestly impracticable to indicate the periods of their movements except in an approximate way. The comparison of two localities distant apart one or two hundred miles will indicate very little. When wider ranges are compared there becomes perceptible a certain proportion in the relations of the general averages. There is always a balance in favor of earlier arrivals in the more southern localities; thus it becomes apparent that the first schools appear in Chesapeake Bay in March and April; on the coast of New Jersey in April and early May;[1] on the south coast of New England in late April and May; off Cape Ann about the middle of May, and in the Gulf of Maine in the latter part of May and the first of June. Returning, they leave Maine late in September or in October; Massachusetts in October, November, and December, the latest departures being those of fish which have been detained in the narrow bays and creeks; Long Island Sound and vicinity in November and December; Chesapeake Bay in December, and Cape Hatteras in January. Farther to the south they appear to remain more or less constantly throughout the year.

It is a strange fact that their northern range has become considerably restricted within the past twenty-five years. Perley, writing in 1852, stated that they were sometimes caught in considerable numbers about Saint John's, New Brunswick, and there is abundance of other testimony to the fact that they formerly frequented the Bay of Fundy in its lower parts; at present the eastward wanderings of the schools do not extend beyond Isle au Haut and Great Duck Island, about forty miles west of the boundaries of Maine and New Brunswick. They have not been known to pass these limits for ten or fifteen years. They have this year hardly passed north of Cape Cod, and forty or more steamers, which have usually reaped an extensive harvest on the coast of Maine, have been obliged to return to the fishing grounds of Southern New England, where Menhaden are found as abundantly as ever.

I have elsewhere shown the arrival of the Menhaden schools to be closely synchronous with the period at which the weekly average of the surface temperatures of the harbors rises to 51° F., that they do not enter waters in which, as about Eastport, Maine, the midsummer surface tem-

[1] The first catch of Menhaden by the fleet in 1881 was off Long Branch, May 8, when Gallup & Holmes' steamer took eight hundred bushels.

peratures, as indicated by monthly averages, fall below 51° F., and that their departure in the autumn is closely connected with the fall of the thermometer to 51° F. and below. In 1877 a cold summer seemed to threaten the success of the Maine Menhaden fisheries. In September and October, however, the temperatures were higher than in the corresponding months of the previous year, and the scarcity of the early part of the season was amply amended for.

The season of 1878 in Maine was fairly successful, the three summer months being warmer than in 1877, but cooler than in 1876. The absence of the Menhaden schools north of Cape Cod in 1879 is also easily explained by the study of temperatures of the water of the Gulf of Maine, as indicated by the observations made in Portland Harbor. The averages for the three summer months are as follows, the numerator of the fraction being the average surface temperature, the denominator that of the bottom: 1876, 62°.5–57°.9; 1877, 58°.5–56°.7; 1878, 61°.5–58°.1; 1879, 56°.1–54°.6.

The average for the three summer months of 1879 is less than that of June, 1876.

This may perhaps be explained by a study of ocean temperatures. In August, 1878, there was a very rapid fall in the temperature of the surface in the Gulf of Maine, so that the average temperature of that month was less than that of July, instead of being higher, as is usual. This may have had the effect of driving the fish into the warmer water of the bays and estuaries. The monthly averages for 1876, 1877, 1878, and 1879 are as follows:

1876—June, 56°.9–54°; July, 66°.7–59°.4; August, 63°.9–60°.4.
1877—June, 54°.9–53°.3; July, 58°.1–56°.3; August, 62°.4–60°.6.
1878—June, 56°.8–55°.2; July, 66°.9–59°.3; August, 60°.7–59°.9.
1879—June, 52°.9–51°.7; July, 55°.9–54°.1; August, 59°.6–58°.

The arrival of the Menhaden is announced by their appearance at the top of the water. They swim in immense schools, their heads close to the surface, packed side by side, and often tier above tier, almost as closely as sardines in a box. A gentle ripple indicates their position, and this may be seen at a distance of nearly a mile by the lookout at the masthead of a fishing vessel, and is of great assistance to the seiners in setting their nets. At the slightest alarm the school sinks toward the bottom, often escaping its pursuers. Sailing over a body of Menhaden swimming at a short distance below the surface, one may see their glittering backs beneath, and the boat seems to be gliding over a floor inlaid with blocks of silver. At night they are phosphorescent. Their motions seem capricious and without a definite purpose; at times they swim around and around in circles; at other times they sink and rise. While they remain thus at the surface, after the appearance of a vanguard they rapidly increase in abundance until the sea appears to be alive with them. They delight to play in inlets and bays, such as the Chesapeake, Peconic, and Narragansett Bays, and the narrow fiords of Maine. They seem particularly fond of shallow waters protected from the wind, in which, if not molested, they will remain throughout the season, *drifting in and out with the tide. Brackish water attracts them, and they abound at the mouth* of streams, especially on the Southern coast. They ascend the Saint John's River more than thirty miles; the Saint Mary's, the Neuse, the York, the Rappahannock, the Potomac nearly to Washington, and the Pawtuxent to Marlborough. They come in with or before the Shad, and are very troublesome to the fishermen by clogging their nets. I am not aware that this difficulty occurs in Northern rivers, though they are found in the summer in the Hudson and its tributaries, the Housatonic, Mystic, Thames, and Providence Rivers, in the creeks of Cape Cod, and at the mouth of the Merrimack. A curious instance of capriciousness in the movements occurred on the coast of Maine, where much alarm was felt, because their habits were thought to have been

changed through the influence of seining. The shore fishermen could obtain none for bait, and vessels followed them far out to sea, capturing them in immense quantities forty miles from land. The fisheries had produced no such effect south of Cape Cod, and it was quite inexplicable that their habits should have been so modified in the north. In 1878, however, after ten years or more, they resumed their former habits of hugging the shores, and the Menhaden fishery of Maine was carried on, for the most part, in the rivers.

Why the schools swim at the surface so conspicuous a prey to men, birds, and other fishes is not known. It does not appear to be for the purpose of feeding; perhaps the fisherman is right when he declares that they are playing.

An old mackerel fisherman thus describes the difference in the habits of the mackerel and Menhaden: "Pogies school differently from mackerel; the Pogy slaps with his tail, and in moderate weather you can hear the sound of a school of them, as first one and then another strikes the water. The mackerel go along 'gilling,' that is, putting the sides of their heads out of the water as they swim. The Pogies make a flapping sound; the mackerel a rushing sound. Sometimes in calm and foggy weather you can hear a school of mackerel miles away." They do not attract small birds as do the schools of predaceous fish. The fish-hawk often hovers above them, and some of the larger gulls occasionally follow them in quest of a meal. About Cape Cod one of the gulls, perhaps *Larus argentatus*, is called "Pogy Gull."

On warm, still, sunny days the fish may always be seen at the surface, but cold or rainy weather and prevailing northerly or easterly winds quickly cause them to disappear. When it is rough they are not so often seen, though schools of them frequently appear when the sea is too high for fishermen to set their nets. The best days for menhaden-fishing are when the wind is northwesterly in the morning, dying out in the middle of the day, and springing up again in the afternoon from the southwest, with a clear sky. At the change of the wind on such a day they come to the surface in large numbers.

A comparison of the effect of the weather upon the Menhaden and the Herring yields some curious results. The latter is a cold-water species. With the advance of summer it seeks the north, returning to our waters with the approach of cold. The Menhaden prefers the temperature of 60° F. or more; the Herring, 55° F. and less. When the Menhaden desert the Gulf of Maine they are replaced by the Herring. Cold weather drives the former to the warmer strata, while it brings the latter to the surface. The conditions most favorable on our coast for the appearance of Herring on the surface, and which correspond precisely with those which have been made out for the coast of Europe, are least so for the Menhaden.

Their winter habitat, like that of the other cold-water absentees, has never been determined. The most plausible hypothesis supposes that instead of migrating towards the tropics or hibernating near the shore, as has been claimed by many, they swim out to sea until they find a stratum of water corresponding to that frequented by them during their summer sojourn on the coast.

This is rendered probable by the following considerations: 1. That the number of Menhaden in southern waters is not diminished in seasons of their abundance on the northern coast, nor increased in those of their absence from the latter region. 2. That there are local varieties of the species, distinguished by physical characters almost of specific value, by differences in habits, and in the case of the southern schools by the universal presence in the mouth of a crustacean parasite, which is never found in the specimens caught north of Cape May. 3. That the same schools usually reappear in the same waters in successive years. 4. That their very prompt arrival in the spring suggests their presence in waters near at hand. 5. That their leanness when they first appear

renders it evident that they have had no food since leaving the coast in autumn. The latter consideration, since they are bottom-feeders, is the strongest confirmation of the belief that their winter home is in the midoceanic substrata.

ABUNDANCE.—As is indicated by the testimony of many observers, whose statements are elsewhere reviewed at length, the Menhaden is by far the most abundant species of fish on the eastern coast of the United States. Several hundred thousand are frequently taken in a single draft of a purse-seine. A firm in Milford, Connecticut, captured, in 1870, 8,800,000; in 1871, 8,000,000; in 1872, 10,000,000; in 1873, 12,000,000. In 1877, three sloops from New London seined 13,000,000. In 1877, an unprofitable year, the Pemaquid Oil Company took 20,000,000, and the town of Booth Bay alone 50,000,000. There is no evidence whatever of any decrease in their numbers, though there can be in the nature of the case absolutely no data for comparison of their abundance in successive years. Since spawning Menhaden are never taken in the nets, no one can reasonably predict a decrease in the future.

FOOD.—The nature of their food has been closely investigated. Hundreds of specimens have been dissected, and every stomach examined by me has been found full of dark greenish or brownish mud or silt, such as occurs near the mouths of rivers and on the bottoms of still bays and estuaries. When this mud is allowed to stand for a time in clear water, this becomes slightly tinged with green, indicating the presence of chlorophyl, perhaps derived from the algæ, so common on muddy bottoms. In addition to particles of fine mud the microscope reveals a few common forms of diatoms.

There are no teeth in the mouth of the Menhaden, their place being supplied by about fifteen hundred thread-like bristles, from one-third to three-quarters of an inch long, which are attached to the gill-arches, and may be so adjusted as to form a very effective strainer. The stomach is globular, pear-shaped, with thick, muscular walls, resembling the gizzard of a fowl, while the length of the coiled intestine is five or six times that of the body of the fish. The plain inference from these facts, taken in connection with what is known of the habits of the Menhaden, seems to be that their food consists in large part of the sediment, containing much organic matter, which gathers upon the bottoms of still, protected bays, and also of the vegetation that grows in such localities. They also, as was demonstrated by Mr. Rathbun in 1880, feed very extensively upon the minute crustaceans, *Copepoda*, etc., which are found in great quantities swimming near the surface in the summer months all along our coast.

Their rapid increase in size and fatness, which commences as soon as they approach our shores, indicates that they find an abundant supply of some kind of food. The oil manufacturers report that in the spring a barrel of fish often yields less than three quarts of oil, while late in the fall it is not uncommon to obtain five or six gallons.

REPRODUCTION.—There is a mystery about their breeding. Thousands of specimens have been dissected since 1871 without the discovery of mature ova. In early summer the genitalia are quite undeveloped, but as the season advances they slowly increase in size and vascularity. Among the October fish a few ovaries were noticed in which the eggs could be seen with the naked eye. A school of large fish driven ashore in November, in Delaware Bay, by the bluefish, contained spawn nearly ripe, and others taken at Christmas time, in Provincetown Harbor, evidently stragglers accidentally delayed, contained eggs quite mature. Young Menhaden from one to three inches in length and upward are common in summer south of New York, and those of five to eight inches in late summer and autumn in the southern part of New England. These are in schools, and make their appearance suddenly from the open ocean like the adult fish. Menhaden have never been observed spawning on the Southern coast, and the egg-bearing individuals when observed are

always heading out to sea. These considerations appear to warrant the theory that their breeding grounds are on the off-shore shoals which skirt the coast from George's Banks to the Florida Keys. There are indications, too, that a small school of Menhaden possibly spawn at the east end of Long Island in the very early spring.

The fecundity of the Menhaden is very great, much surpassing that of the Shad and Herring. The ovaries of a fish taken in Narragansett Bay, November 1, 1879, contained at least 150,000 eggs.

ENEMIES.—Among its enemies may be counted every predaceous animal which swims in the same waters. Whales and dolphins follow the schools and consume them by the hogshead. Sharks of all kinds prey upon them largely; one hundred have been taken from the stomach of one shark. All the large carnivorous fishes feed upon them. The tunny is the most destructive. "I have often," writes a gentleman in Maine, "watched their antics from the masthead of my vessel—rushing and thrashing like demons among a school of fish; darting with almost lightning swiftness, scattering them in every direction, and throwing hundreds of them in the air with their tails." The pollock, the whiting, the striped bass, the cod, the squeteague, and the gar-fish are savage foes. The sword-fish and the bayonet-fish destroy many, rushing through the schools and striking right and left with their powerful swords. The bluefish and bonito are, however, the most destructive enemies, not even excepting man; these corsairs of the sea, not content with what they eat, which is of itself an enormous quantity, rush ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments. Traces of their carnage remain for weeks in the great "slicks" of oil so commonly seen on smooth water in summer. Professor Baird, in his well-known and often-quoted estimates of food annually consumed by the bluefish, states that probably ten thousand million fish, or twenty-five million pounds, daily, or twelve hundred million million fish and three hundred thousand million pounds are much below the real figures. This estimate is for the period of four months in the middle of the summer and fall, and for the coast of New England only.

Such estimates are professedly only approximations, but are legitimate in their way, since they enable us to appreciate more clearly the luxuriance of marine life. Applying similar methods of calculation to the Menhaden, I estimate the total number destroyed annually on our coast by predaceous animals at a million million of millions; in comparison with which the quantities destroyed by man, yearly, sink into insignificance.

It is not hard to surmise the Menhaden's place in nature; swarming our waters in countless myriads, swimming in closely packed, unwieldy masses, helpless as flocks of sheep, near to the surface and at the mercy of every enemy, destitute of means of defense and offense, their mission is unmistakably to be eaten.

In the economy of nature certain orders of terrestrial animals, feeding entirely upon vegetable substances, seem intended for one purpose—to elaborate simple materials into the nitrogenous tissues necessary for the food of other animals, which are wholly or in part carnivorous in their diet; so the Menhaden feeding upon otherwise unutilized organic matter is pre-eminently a meat-producing agent. Man takes from the water every year eight or nine hundred millions of these fish, weighing from two hundred to three hundred thousand tons, but his indebtedness does not end here; when he brings upon his table bluefish, bonitoes, weak-fish, sword-fish, or bass, he has before him usually Menhaden flesh in another form.

USES.—The commercial importance of the Menhaden has only lately been rightly appreciated. Twenty-five years ago and before, it was thought to be of very small value. A few millions were taken every year in Massachusetts Bay, Long Island Sound, and the inlets of New Jersey. A small portion of these were used for bait; a few barrels occasionally salted in Massachusetts to be exported to the West Indies. Large quantities were plowed into the soil of the farms along the

shores, stimulating the crops for a time, but in the end filling the soil with oil, parching it and making it unfit for tillage. Since that time manifold uses have been found. As a bait-fish this excels all others; for many years much the greater share of our mackerel was caught by its aid, while the cod and halibut fleet use it rather than any other fish when it can be procured. The total consumption of Menhaden for bait in 1877, did not fall below 80,000 barrels, or 26,000,000 fish, valued at $500,000. Ten years before, when the entire mackerel fleet was fishing with hooks, the consumption was much greater. The Dominion mackerel fleet buy Menhaden bait in quantity, and its value has been thought an important element in framing treaties between our government and that of Great Britain.

As a food resource it is found to have great possibilities. Many hundreds of barrels are sold in the West Indies, while thousands of barrels are salted down for domestic use by families living near the shore. In many sections they are sold fresh in the market. Within six years there has sprung up an important industry, which consists in packing these fish in oil, after the manner of sardines, for home and foreign consumption. In 1874 the production of canned fish did not fall below 500,000 boxes.

The discovery made by Mr. S. L. Goodale, that from these fish may be extracted, for the cost of carefully boiling them, a substance possessing all the properties of Liebig's "Extract of beef," opens up a vast field for future development. As a food for the domestic animals in the form of "fish meal," there seems also to be a broad opening. As a source of oil, the menhaden is of more importance than any other marine animal. Its annual yield usually exceeds that of the whale (from the American fisheries) by about 200,000 gallons, and in 1874 did not fall far short of the aggregate of all the whale, seal, and cod oil made in America. In 1878 the menhaden oil and guano industry employed capital to the amount of $2,350,000, 3,337 men, 64 steamers, 279 sailing vessels, and consumed 777,000,000 fish; there were 56 factories, which produced 1,392,644 gallons of oil, valued at $450,000, and 55,154 tons of crude guano, valued at $600,000; this was a poor year. In 1874 the number of gallons produced was 3,373,000; in 1875, 2,681,000; in 1876, 2,992,000; in 1877, 2,427,000. In 1878 the total value of manufactured products was $1,050,000; in 1874 this was $1,809,000; in 1875, $1,582,000; in 1876, $1,671,000; in 1877, $1,608,000. It should be stated that in these reports only four-fifths of the whole number of factories were included. In 1880 the number of persons employed in the entire industry was placed at 3,635, the amount of capital invested $2,362,841, the value of products $2,116,787, including 2,066,396 gallons of oil, worth $733,424, and 68,904 tons of guano, worth $1,301,217. The refuse of the oil factories supplies a material of much value for manures. As a base for nitrogen it enters largely into the composition of most of the manufactured fertilizers. The amount of nitrogen derived from this source in 1875 was estimated to be equivalent to that contained in 60,000,000 pounds of Peruvian guano, the gold value of which would not have been far from $1,920,000. The yield of the menhaden fishery in pounds is probably triple that of any other carried on by the fishermen of the United States.

In estimating the importance of the Menhaden to the United States, it should be borne in mind that its absence from our waters would probably reduce all our other sea-fisheries to at least one-fourth their present extent.

175. THE GULF MENHADEN—BREVOORTIA PATRONUS.

In addition to the common Menhaden, a second North American species has recently been discovered.[1] This species has been reported only from the Gulf of Mexico, where the following observations were made by Mr. Silas Stearns:

[1] See Report United States Commission Fish and Fisheries, part v, pp. 17 and 26, and Proceedings of the United States National Museum, vol. i.

POPULAR NAMES.—"The Gulf Menhaden has several vernacular names. At Key West it is called 'Sardine,' in common with other fish of the same general appearance. At Apalachicola, Pensacola, and Mobile it is called 'Alewife'; at New Orleans the names 'Sardine' and 'Alewife' are both in use, the latter perhaps more generally. On the Texan coast it is known as 'Herring,' 'Alewife,' 'Sardine,' and 'Shad,' each locality having its peculiar name.

"I have observed the Gulf Menhaden from Key West to the Texan coast, and am told that its range extends along the Mexican coast. It seems to be most abundant along the coast between Cedar Keys and New Orleans. On other parts it is only an ordinarily common fish or an occasional visitor. My observations have been made at Pensacola, where their movements are as follows: On the first calm, warm days of April many small schools appear in the bays and sounds. From the first appearance of these schools they can be seen at all times in fine weather until late in the summer, when they disappear. They remain in these bays until late in November and December, but keep to deeper waters, and are seen, after the close of summer, only when taken in nets.

MOVEMENTS.—"The first which arrive measure only five to six inches. In June they average seven inches, and schools have been observed composed of fish of different sizes, as five, six, seven, and eight inches long. In July the average size is about eight inches, and in August, September, and October the individuals composing the schools measure seven, eight, nine, and ten inches in length. Those fish caught in October and November in nets are eleven, twelve, and thirteen inches long, and are probably full-grown. In fine weather they are first seen approaching the coast in large schools, but if windy and cold they are not seen until they have entered the bay and the weather has become pleasant. When once inside the large schools are broken up into many small schools, which swim at the surface, rippling the water as they go. Their movements seem not to be affected by the tide. Their favorite feeding or playing grounds are in quiet bayous, creeks, and nooks in the bay, where they are unmolested by larger fishes of prey. Brackish water is also much sought by them, and I think most, if not all, of them visit it some time during the season. A person stationed at the mouth of a fresh-water stream or river, in August or September, will see little schools of these fish swimming round and round at the surface, just where the two kinds of water meet. As they become accustomed to the fresh water they enter the stream and move upwards until they reach a quiet creek or bayou. How long they stay in the river I cannot determine, for I have noticed as many moving down as up stream. Late in September and October very few or none are seen at the surface of the water, but I have caught many in the river and at its mouth at that season, proving that they are still present. About the first of November I have known of a few being taken in gill-nets in or about the rivers. During the months September and October they are rarely seen in salt water, but come to notice again in November, by being taken in small quantities in seines along the outside beaches with other fish, such as bluefish, channel bass, and sheepshead. After a few catches in November and December we see or hear nothing more of them until the following spring; but from this we cannot safely conclude that they have left these waters, for the proper nets (gill-nets) in which to catch them in deep water are but little used in this vicinity, and if they remained they would not be observed.

MESSMATES.—"When the Gulf Menhaden arrive in spring, each one has a parasite in its mouth, a crustacean called *Cymothoa prægustator*. This animal is found always in one position, clinging with its hooked claws to the roof of the fish's mouth, with its head looking outward and very near to the jaw of the fish. These parasites remain with the Menhaden as long as the latter is in salt water; in brackish water they are less frequently observed, disappearing altogether in fresh water. With all the fall fish of this species which I have examined there were no parasites. The fish do

not seem to suffer physically from the company of this parasite, but I have fancied that it was to get rid of them that the fish visit fresh water. I have noticed no other parasites upon them.

REPRODUCTION.—"The first traces of spawn are found in May. By July it has become sufficiently developed to be noticed by any person unaccustomed to the examination of such objects. In the latter part of September or first of October, at which time they are last seen in abundance, the ovaries are sufficiently grown to distend the fish's abdomen, yet not fully ripe. When they are next caught, in November and December, on the sea-beach, they are without ovaries and show signs of having spawned.

FOOD.—"The Gulf Menhaden are bottom-feeding fish, as their stomachs always contain soft brown mud, from which I suppose it extracts microscopic animal or vegetable matter. Some believe that it gains its nourishment in the shape of animalculæ from the water, as it swims along with its mouth open, straining water through its gills. It is not a food-fish. A few trials have been made to use them as bait for deep-sea fish, such as red snappers, groupers, etc. Such experiments have proved successful."

S. THE SHAD AND THE ALEWIVES.

By MARSHALL MCDONALD.

176. THE RIVER HERRINGS, OR ALEWIVES—CLUPEA ÆSTIVALIS AND C. VERNALIS.

HISTORY AND NOMENCLATURE.—Early writers on American fishes, especially Mitchill and De Kay, seem to have experienced great difficulty in differentiating into species the various forms of river Herring or Alewives in our waters. These early writers were, however, apparently more discriminating than some of their successors, for they recognized differences which have been ignored by subsequent writers. They were as much at fault, however, in making too many species as were Storer and Gill in uniting all the forms under one specific name. Mitchill recognized seven species, to wit, the "New York" Herring, *Clupea halec;* the "Tiny" Herring, *C. pusilla;* the "Little" Herring, *C. parvula;* the "Sprat" Herring of New York, *C. indigena;* the "Spring" Herring or "Alewife," *C. vernalis;* the "Summer" Herring of New York, *C. æstivalis;* and the "Blue" Herring, *C. cærulea;* all of which are apparently founded upon hasty studies of individuals of different ages and varying proportions, and in reality belong to the two species named in the heading of this article. The work of Mitchill is valuable, since by him were well defined the two species which we recognize at the present time under the names now accepted by us, the "Spring" and "Summer" Herrings, respectively *C. vernalis* and *C. æstivalis.* These are described in such terms that they cannot be mistaken. It is not worth while to attempt an identification of the other species, most of which are evidently based upon very small individuals.

De Kay took up and discussed under the same or different names most of the forms enumerated by Mitchill, and, taking advantage of his more accurate methods of description, we are able to form a very satisfactory idea of what was intended under each name. The *Alosa tyrannus* of De Kay corresponds to the *C. vernalis* of Mitchill, while the *C. vernalis* of De Kay, in the synonym of which he cites Mitchill's *C. halec,* is without much doubt the summer Herring of Mitchill, although De Kay loses sight of Mitchill's name *C. æstivalis.* The *C. fasciata* of De Kay, to which he, without hesitation, refers Mitchill's *C. pusilla,* is probably the young of the summer Herring.

It is useless to attempt to trace throughout the entire literature on the subject the various errors in the identification of the river Herrings. Storer, in his "History of the Fishes of Massachusetts," distinguishes the two species under the names *Alosa cyanonoton* and *A. tyrannus,* and supplies figures of each. These are not, however, sufficiently characteristic to be serviceable in identification. The name *tyrannus,* which was used by both De Kay and Storer for the spring Herring, belongs by rights to the Menhaden, as has been elsewhere demonstrated.

Douglass in his "North America," Boston and London, 1740, remarks, in speaking of New England:

"Alewives by some of the country people are called Herrings. They are of the Herring tribe, but somewhat larger than the true Herring. They are very mean, dry, and insipid fish. Some of them are cured in the manner of white Herrings, and sent to the sugar islands for the slaves, but because of their bad quality they are not in request; in some places they are used to manure land. They are very plenty, and come up the rivers and brooks into ponds in the spring. Having

spawned, they return to the sea. They never take the hook. Many fish go up the rivers into ponds earlier or later in the spring to spawn, viz, salmon, Shad, Alewives, tomcod, smelts, etc., and many good laws have been made in New England to prevent the obstruction of their passage by weirs, etc., as they are of great benefit to the inhabitants near these rivers and ponds."

From 1861 until 1880 nearly all American zoologists were contented to consider the various kinds of river Herrings as members of a single species, which was designated *Pomolobus pseudo-harengus*, the specific name *pseudo-harengus* having originated in Wilson's article in volume ix of the American edition of Rees' Encyclopædia. There is no positive evidence to prove that this volume was published prior to Mitchill's work on the "Fish of New York," which appeared in 1815, and in which the names now accepted by us were first proposed. The American edition is said by Allibone to have been in course of publication from 1809 to 1820. There is, however, no date upon the title-page of volume ix, and consequently the priority of the name *pseudo-harengus* over the others is doubtful. At any rate, the description given by Wilson is so vague that it cannot well be assigned to one species in preference to the others.[1] If it is to be assigned to either, it most assuredly belongs to the species which Mitchill calls *C. vernalis*, and which is characterized by its long head, large eye, and high fin. Wilson, however, did not distinguish the two species, and his intention was evidently to include them both under one name. The only specific characteristic given is the date of its advent, which, according to him, precedes that of the Shad by about three weeks. Since there is no statement of the locality where this occurs, this also is quite indefinite. Taking into consideration also the fact that Wilson's article was published anonymously in a book without date, I think we can safely set aside the name *pseudo-harengus* and consider that the two names used by Mitchill in the discussion of his spring and summer Herrings are definitely assigned to these two species.

The attention of the zoologists of the Fish Commission was first called to the probable existence of two species by the persistent opinions of the fishermen of the Potomac, who recognized two forms—differing in habit and in general appearance—which they called the "Branch" Herring and the "Glut" Herring respectively. The late Mr. Milner, in the course of his river work, as early as 1876, came to the conclusion that the two forms were specifically distinct, but the problem was not definitely worked out until 1879. The announcement of the discovery of the two species and a definition of their characters were first published in the report of the Virginia Fish Commission for 1879.

These species may easily be distinguished from each other by the following characters: *C. æstivalis* is more elongate in form, has a lower body, less elevated fins, and smaller eyes than *C. vernalis*. The proportions of the bones of the head in *C. æstivalis* differ from those in *C. vernalis*, as also does the coloration of the lining of the abdomen, which in *C. æstivalis* is black, and in *C. vernalis* gray.

The popular names applied to these fishes differ in almost every river along the coast. *C. vernalis* is known along the Potomac River as the "Branch" Herring; on the Albemarle River as the "Big-eyed" Herring and the "Wall-eyed" Herring; in Canada it is known as the "Gaspereau" or "Gasperôt." It is pre-eminently the "Alewife" of New England; the "Ellwife" or "Ellwhop" of the Connecticut River. The other species, *C. æstivalis*, undoubtedly occurs occasionally in its company, but is probably not common in the Connecticut and Housatonic Rivers, and in many parts of Massachusetts is distinguished by another name.

[1] "*Pseudo-harengus* (American Herring). Body above ash-color, inclining to dull greenish-blue; sides and belly silvery; no spots on the sides; head small, tapering; under jaw little longer; ascends our rivers from the sea with the Shad to deposit their eggs in shallow water; they are about three weeks in advance of the Shad; well tasted either fresh or salted, but not so fat as European Herring."

From the "Collections of the Massachusetts Historical Society, 1816,"[1] are taken the following physiological and historical notes on the occurrence of the Alewife at Wareham, Massachusetts:

"Of the Alewife there are evidently two kinds, not only in size but habit, which annually visit the brooks passing to the sea at Wareham. The larger, which set in some days earlier, invariably seek the Weweantitt sources. These, it is said, are preferred for present use, perhaps because they are earliest. The second, less in size, and usually called 'Black backs,' equally true to instinct, as invariably seek the Agawam. These are generally barreled for exportation. In the sea, at the outlet of these streams, not far asunder, these fish must for weeks swim in common, yet each selects its own and peculiar stream. Hence an opinion prevails on the spot that these fish seek the particular lake where they were spawned.

"Another popular anecdote is as follows: Alewives had ceased to visit a pond in Weymouth, which they had formerly frequented. The municipal authorities took the usual measures, by opening the sluiceways in the spring at mill-dams, and also procured live Alewives from other ponds, placing them in this, where they spawned, and sought the sea. No Alewives, however, appeared here until the third year;[2] hence three years have been assumed by some as the period of growth of this fish.

"These popular opinions, at either place, may or may not agree with the laws of the natural history of migratory fish.

"The young Alewives we have noticed to descend about the 20th of June and before, continuing so to do some time, when they are about two inches long, their full growth being from twelve to fifteen inches. We have imbibed an opinion that this fish attains its size in a year, but if asked for proof we cannot produce it.

"These fish, it is said, do not visit our brooks in such numbers as in former days. The complaint is of old date. Thus, in 1753, Douglass remarks on migratory fishes: 'The people living upon the banks of Merrimack observe, that several species of fish, such as salmon, Shad, and Alewives, are not so plenty in their seasons as formerly; perhaps from disturbance, or some other disgust, as it happens with Herrings in the several friths of Scotland.' Again, speaking of Herrings, he says: 'They seem to be variable or whimsical as to their ground.' It is a fact, too, that where they most abound, on the coast of Norway and Sweden, their occasional disappearance is a subject of remark.[3]

"The Herring is essentially different from the Alewife in size (much smaller) and in habit. It continues, we believe, in the open sea, and does not seek pond-heads. Attempts are sometimes made, by artificial cuts, to induce them to visit ponds which had not before a natural outlet. These little cuts, flowing in the morning, become intermittent at noon, as the spring and summer advance. Evaporation, therefore, which is very great from the surface of the pond, should, probably, be considered in the experiment, making the canal as low as the midsummer level of the pond, otherwise it may be that the fish perish in the passage. This may, in other respects, have its inconveniences, at seasons when the ponds are full.

"The town of Plymouth, for a series of years, annually voted from one thousand to five hundred and two hundred barrels of Alewives to be taken at all their brooks, in former years.

"In the year 1730, the inhabitants were ordered not to take more than four barrels each; a

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[1] Vol. iv, second series, pp. 294–296.

[2] This anecdote was related in a circle of the members of the general court at Boston, when a member from Maine remarked that a similar event had occurred in his vicinity.

[3] Previous to 1752 the Herrings had entirely disappeared seventy-two years on the coast of Sweden; and yet, in 1782, 139,000 barrels were cured by salt at the mouth of the Gothela, near Gottenburg.—STUDIES OF NATURE.

large individual supply indeed, compared with the present period (1815), when it is difficult for an householder to obtain two hundred Alewives, seldom so many.

"In 1762, at a vendue the surplus appears to have been sold in twenty-five barrel lots, which sold at 3*s.* 7*d.* and 4*s.* the barrel. In 1763, Plymouth and Wareham took one hundred and fifty barrels at the Agawam brook;[1] two hundred barrels was the usual vote, down to a modern date, perhaps 1776. Menhaden were also taken in quantity at Wareham, and barreled for exportation, in former years."

The *C. æstivalis* is the "Glut" Herring of the Albemarle and the Chesapeake, and the "English" Herring of the Ogeechee River. In the Saint John's River, Florida, it is known simply as the "Herring." On the coast of Massachusetts it is called the "Blue-back," a name which is common to the late runs of the same species of the Rappahannock. Around the Gulf of Maine this species is also known by the names "Kyack" or "Kyauk," "Saw-belly," and "Cat-thrasher." Although the coast fishermen of Massachusetts and Maine claim to distinguish the two species, the "Blue-backs" and the "Alewives," their judgment is by no means infallible, for I have frequently had them sort out into two piles the fishes which they distinguish under these names, and found that their discrimination was not at all reliable. The features to which they mainly trusted in the determination of *C. æstivalis* are the bluer color of the back and the greater serration upon the ventral-ridge. The other species, when the scales on its back are rubbed off, is as blue as this, and the serration of the belly is dependent entirely upon the extent to which the back has become stiffened in the death struggle and the consequent degree of arching of the ventral ridge. The young of one or both species are sold in the Boston markets under the name "Sprats," and in New York they make up a large proportion of the so-called "Whitebait." In the report of the Massachusetts Commissioner of Fisheries for 1869, Col. Theodore Lyman called attention to the probable occurrence of two species in Massachusetts, but his diagnostic characters seem hardly well chosen. The form which he calls the "Gray-back" is undoubtedly *C. vernalis*, and the "Black-bellies," which he is inclined to believe distinct, would appear to be another run of the same species. The river Herring, which he speaks of as a large variety, not much esteemed, and supposed to spawn in tidal water, may possibly be the same as *C. æstivalis*. The Black-bellies, if their habits are properly described, have much in common with *C. æstivalis*. There is, however, much to be learned concerning all the fishes of this group, and it is more than probable that careful study will reveal facts of which we are at present entirely ignorant.

ABUNDANCE.—The Alewife is by far the most abundant of our river fishes, and throughout the whole Southern region where they are caught, together with the Shad, the number of individuals is not far from ten to twenty times as great as that of the Shad. For instance, in the Albemarle region, in 1879, 750,000 Shad were taken and upwards of 20,000,000 Alewives. Again, in 1880, about 600,000 Shad were taken from the Potomac, and 11,000,000 Alewives. By far the greatest number of the Alewives thus taken were "Glut Herring," *C. æstivalis;* but, since the two species are sold together, without discrimination, no accurate statement of proportional numbers can be made. In the Northern rivers they are not taken in any great numbers, owing to the fact that the meshes of the nets used in the capture of the Shad are too large to retain the fish. In the Connecticut and other rivers a large mesh is required by law, but throughout this entire region the abundance of valuable sea-fishes is so great that there could be but little gain in capturing the Alewives. There is on Cape Cod an extensive alewife fishery, described in another chapter. This has for more than a century been regulated by law, and the fish are allowed during stated periods to swim without interruption to their spawning beds. The streams in which they are taken are so

[1] Plymouth retains a fishing privilege in this brook within Wareham. The Alewives, arewe told, were more numerous in 1815 than for some years.

small, and the fish in their ascent so crowded together, that they appear to be extremely abundant, although the aggregate catch for the entire Cape is not perhaps much greater than the yield of many single seines in the South. Here, however, there has been no great decrease in abundance, while in the South the herring fishery is much less productive than in former years. Even now, however, the great seines of the Potomac and Albemarle regions could not be operated without the herring fishery, and hauls are yearly made which seem incredible to those who have not seen them. In 1879, at Wood's fishery, on the Albemarle, three hundred thousand Alewives were landed at a single haul of the seine. Hauls of half a million, and even more, were not unfrequent prior to the late war. Considerable quantities of these fish are taken yearly in the weirs on the south coast of New England, and form an important element in the bait supply of the Massachusetts fishing fleet. In the report of the Massachusetts Commissioner of Fisheries for 1872 are given the statistics of the catch of the Waquoit weir for seven years, from 1865 to 1871, inclusive, the yearly average being 105,000. The annual product of two streams emptying into the head of Buzzard's Bay is given in the same place,[1] one for fifteen, the other for seven years; the average annual yield of the first was 539,000, that of the second 366,000. In 1864 the yield was 804,000. Numerous details of a similar character may be found by those who are interested in the statistical part of this report.

South of Cape Fear River the Alewife occurs in all the Atlantic streams in considerable quantities, but as yet their capture is apparently not of such importance to the fishermen as to cause the formation of a special alewife fishery between that point and the great fisheries of the Albemarle.

In the works of early writers occur allusions to the Alewives of our Eastern coast, which appear, in almost every instance, to refer to all the fishes known under that name. In Josselyn's "Account of Two Voyages to New England," 1675, he remarks:

"The *Alewife* is like a *Herrin*, but has a bigger bellie; therefore, called an *Alewife;* they come in the end of April into fresh Rivers and Ponds; there hath been taken in two hours' time by two men without any Weyre at all, saving a few stones to stop the passage of the River, above ten thousand."

Captain John Smith, in his "Advertisements for the Inexperienced Planters of New England," London, 1631,[2] remarked:

"The seven and thirty passengers miscarrying twice upon the coast of *England*, came so ill-provided, they onley relyed upon the poore company they found, that had lived two yeares by their naked industry, and what the country naturally afforded; it is true, at first there hath been taken a thousand Bayses at a draught, and more than twelve hogsheads of Herrings in a night; of other fish when and what they would, when they had meanes; but wanting most necessaries for fishing and fowling, it is a wonder how they could subsist, fortifie themselves, resist their enemies, and plant their plants."

Thomas Morton, in his "New England Canaan," London, 1632, remarks:

"Of Herrings, there is a great store, fat, and faire; & (to my minde) as good as any I have seene, & these may be preserved, and made a good commodity at the Canaries."

Mr. Higginson, in his "New England's Plantation," 1630, refers to the great abundance of Herring in the waters of New England.

In the "Chronicles of the Pilgrim Fathers of the Colony of Plymouth," from 1692 to 1725, speaking of Town Brook, Plymouth, Massachusetts, it is stated that before the brook was so much impeded by dams vast quantities of Alewives passed up through it annually to Billington Sea.

[1] Page 30.

[2] Page 19.

William Wood, in his "New England's Prospects," London, 1634, remarks:

"The Herrings be much like them that be caught on the *English* coast. *Alewives* be a kind of fish which is much like a Herring, which in the latter end of Aprill come up to the fresh Rivers to spawne, in such multitudes as is almost incredible, pressing up in such shallow waters as will scarce permit them to swimme, having likewise such longing desire after the fresh water ponds, that no beating with poles, or forcive agitations by other devices, will cause them to returne to the sea, till they have cast their spawne."

The same writer makes mention of the fact that in the spring, when the Alewives pass up the rivers, abundance of bass may be caught in the rivers.

Wood, writing in 1633, states that a little below the fall in Charles River the inhabitants of Watertown had built a *weir* to catch fish, wherein they took great store of Shads and Alewives. "In two tides they have gotten 200,000 of these fishes."

Schoepf, in his "Fishes of New York," 1788, refers to the American Herring under the name *C. harengus*, stating that it is similar to that of Europe, but that the body has scales which are more easily detached. The back is glistening blue, the belly white, widely carinate, and provided with saw-like scutes. The fish which he has in mind is undoubtedly one of the river Herrings, since he states that it appears in May and June on the coast of New York, later than the Shad and not in such great numbers.

Pennant, in his "Arctic Zoology," states that "Herrings leave the salt water in March and run up the rivers and shallow streams of Carolina in such numbers that the inhabitants fling them ashore by shovels full. Passengers trample them under foot fording the rivers. They are not so large as the 'English,' but exceed them in flavor when pickled."

GEOGRAPHICAL DISTRIBUTION.—The geographical distribution of the two species has not been thoroughly worked out, but as now understood may be stated as follows: The "Blue-back," or "Glut" Herring, *C. æstivalis*, Mitchill, occurs in the Saint John's River, Florida, and in all the coast waters of the Eastern United States to the Gulf of Maine. On the coast of Maine this species rarely enters rivers, but is found abundantly at sea. It is probably the "Spring" Herring referred to by Col. Theodore Lyman as occurring below the dams in the rivers of Massachusetts. Its area of greatest abundance is in the Albemarle and Chesapeake regions. The name of "Glut" Herring is derived from the fact that it makes its appearance in great schools, and all at once becomes so abundant as to glut the markets. The former appears later than the "Spring" Herring, or "Gaspereau," and some time after the Shad. Its advent is much less gradual than that of the "Spring" Herring. Its peculiar movements are due to certain conditions of temperature, which will be discussed below.

At present, as the latest investigations show, the river range of this species in the Southern States does not extend far beyond tide water. In early days, before obstructions were placed in the James River, they are said to have ascended as far as Lexington; now they do not reach the vicinity of Richmond, although there are no obstructions below that city. The "Spring" Herring, or Gaspereau, *C. vernalis*, Mitchill, is more northerly in its range. Until discovered by Colonel McDonald in the Neuse River of North Carolina, in the spring of 1880, it had not been definitely recorded south of the Chesapeake Bay. Although in that year this species was particularly abundant in the Albemarle and Chesapeake regions, constituting a considerable portion of the entire catch, it is ordinarily much less numerous, and the area of its greatest abundance is in the region from the Gulf of Saint Lawrence to Cape May. As has already been stated, the Alewives of the Connecticut River are chiefly of this species, as also is the Herring of the Hudson and of the streams emptying into Cape Cod. In the Chesapeake region this species is from three to four

weeks earlier than the other, reaching the maximum of its abundance and beginning to decline in numbers before the other comes. The approach of the latter is more gradual, and unlike the other species, it makes its way into the small streams and branches; hence the name "Branch" Herring. In the rivers of Massachusetts the "Branch" Herring ascends much farther toward the headwaters than the other species, and in some streams is found to the exclusion of the other—facts which will be discussed below when considering the influences of temperature. Perley states that the Gaspereau appears in the harbor of Saint John's in April, but the main body does not enter the river before May 10; that the fish is abundant in the Bay of Fundy, but that the species is less plentiful and smaller in the Gulf of Saint Lawrence. He also states that in the Bay of Chaleur it has never been noticed, and that, as in the case of Shad, the Bay of Merrimachi would appear to be its extreme northern limit. It ascends the river of the same name to its source, spawning in the Merrimachi Lake. In the Saint John's River, New Brunswick, it ascends to Darling's Lake (Kennebecasis), Douglas Lake (Nerepis), the Washademoac Lake, the Oenabog Lake, the Grand Lake, and the Oromocto River, and in company with the Shad deposits its spawn. Its abundance in the harbor of Saint John, New Brunswick, may be inferred from the fact that the catch varies from twelve to sixteen thousand barrels each season, sometimes reaching twenty thousand. This statement was made in 1852.

A very remarkable phenomenon, recently observed, has been the appearance of this species in immense numbers in Lake Ontario and lakes of New York. Dr. T. H. Bean has collected a large number of facts upon this point, which are recorded in an essay at the end of this chapter.

MIGRATIONS AND MOVEMENTS.—Like the Shad, the Alewives are anadromous in habit. The dates of their first appearance in any given river may be very closely determined by an examination of the tables which show the movements of the Shad. The Gaspereau or "Spring" Herring usually precedes the Shad by a period of several weeks, while the run of the "Blue-back" or "Glut" Herring occurs in the middle of the shad season.

In 1879 the first Shad made their appearance in the markets of Washington March 25, preceded four weeks by the Menhaden, a little more than three weeks by the Branch Herring, and about four weeks in advance of the "Glut" Herring. Colonel Lyman, in his report for 1872, already referred to, gives the dates of the appearance of the Alewives, Menhaden, and bluefish at Waquoit weir for thirteen years, from 1859 to 1871 inclusive. The Alewives always came first, from March 24 to April 7; the scup from a month to forty days later; the Menhaden about the same time with the scup, though usually two or three days later; and the bluefish from ten days to two weeks after the Menhaden.[1]

Concerning the time of their departure from the river as little is known as in the case of the Shad. Their winter habitat has yet to be found. I am convinced, after several years of study, that in mild winters they remain about the mouths of the rivers, ascending them in the spring. Late in December, 1879, he captured numerous specimens of both species in gill-nets, at Yorktown, in company with Menhaden, and it is my opinion that they might be taken in a similar manner in Pamlico Sound. Thus, also, it is possible that many Shad winter in Long Island Sound and New York Bay, but we know that in the fall they are found in abundance forty or fifty miles at sea in the Gulf of Maine. The Branch Herrings ascend the river probably as far as the Shad, and are believed to penetrate small streams to a much greater distance, entering many waters in which the Shad never occur. The "Blue-back" or "Glut" Herring, however, does not go far above tide water, and the area of reproduction seems to be confined to the large streams or to their tidal tributaries.

[1] Report of Massachusetts Commissioner of Inland Fisheries, January, 1874, p. 64.

FOOD.—As in the case of the Shad, very little is known concerning the food of the river Alewives in their salt-water habitats. It is, however, supposed that they, like other similar species, exist largely upon swimming crustaceans. When in the rivers they do not feed to any considerable extent, although they have been known in many instances to take the fly.

REPRODUCTION.—The eggs of the Alewife are adhesive, like those of the sea Herring, though to a much less degree. The number of eggs varies from sixty thousand to one hundred thousand, in accordance with the size of the individual. They are deposited upon the bottom in shoal water, or on whatever object they may come in contact with. The time for spawning, after the fish have entered the river, depends, as in the case of the Shad, entirely on the temperature of the water. The spawning of the "Glut" Herring takes place under ordinary conditions at a temperature of 70° to 75° F.; that of the "Branch" Herring, when the water is as low as 55° to 60° F. The period of development varies directly with the temperature.

The season of incubation with the "Glut" Herring is about the same as with the Shad—that is, about three or four days. With the "Branch" Herring the spawning takes place when the water is colder, for which reason the period of incubation is doubtless longer. The young Alewife before winter attains a length of two to three inches, and the period of growth continues, probably, as in the Shad, for three or four years.

"There seems to be," remarks Professor Baird,[1] "a difference of opinion as to the age at which Alewives first return from the sea, some fixing it at two and others at three or more years. Captain Treat, of Eastport, however, many years ago transported several hundred pairs of breeding fish to a small sheet of water, known as Keene's Pond, situated some five or six miles from Robinston, Maine, and having its outlet into the Calais River just below Red Beach. The level of the lake is several hundred feet above that of the river, and the outlet is very precipitous, consisting of several falls entirely impassable to fish from below. No Alewives had ever been known in this pond at the time of their introduction by Captain Treat. The young fish were seen i : the pond in the course of the summer in myriads, all of them disappearing, however, after a heavy rain in the autumn, which swelled the waters to produce a sufficient discharge. Due examination was made for successive years, but not until the expiration of the fourth were they seen, when the outlet was observed to be almost choked up by a solid mass of Alewives, struggling to make their way back again to the place of their birth."

During past years the Alewife has frequently been artificially introduced into new waters or over dams by the transportation of fish of considerable size. This is constantly done on Cape Cod in the restocking of the herring streams which have been exhausted, and was successfully accomplished by General N. L. Lincoln, in Maine, as long ago as 1750. Colonel Lyman, in his report for 1870,[2] describes the experiment by Mr. E. S. Haddoway in restocking Eel River, Town Brook, Plymouth, in 1865. The crop sown by him in that year came up in 1869 in the shape of a good run of fish, chiefly males full grown.

Herring eggs have frequently been artificially impregnated by men engaged in shad culture. The young fish artificially hatched have in some instances been transported. In 1882 two million were sent to Texas by the United States Fish Commission and deposited in the Colorado River. Artificial hatching would seem less necessary in the case of the Alewife than in that of the Shad, since with the former, owing to its peculiar spawning habits, the eggs stand a better chance of hatching out, and very slight protection of the fish during spawning season will be sufficient to keep up the supply. The present law of the District of Columbia, by which pound-nets are kept

[1] Report, United States Fish Commission, part ii, 1874, p. lxi. [2] Page 7.

out of the water after June 1, will doubtless have a very important effect in keeping up the supply of Alewives in the Potomac.

SIZE.—According to the ordinary mode of estimating the weight of River Herring in the Potomac three make a pound, and the maximum weight per individual does not exceed half a pound.

USES.—The Herrings, or Alewives, taken in the great fisheries of the South, are almost without exception salted for local consumption, though early in the season they are shipped fresh from the Albemarle region to Philadelphia, New York, and Baltimore, and are sold in the markets at a low price. There is of course a considerable consumption in the fresh state in the region of the fisheries, immense quantities being taken by peddlers and carried by wagons inland from the rivers of the South, as well as from the Hudson, Connecticut, and smaller rivers of Massachusetts. Great numbers are smoked in North Carolina for local consumption; in fact, almost all which are used in the vicinity of the fisheries are taken out of the brine (after having been saturated with the salt, or "struck" or "corned") and hung up for a few days in the smoke-houses belonging to the purchasers who intend them for their own use.

When intended for shipment into the interior they are treated in several ways: (*i*) They may be taken out of the first pickle and packed in dry salt; in that case they are called "salt Herring." (*ii*) The roe Alewives may be selected, the heads and entrails removed and salted down in dry salt and sent to market as roe Alewives, of which there are several grades. (*iii*) They may be packed as split Alewives. In this operation the heads and entrails are removed by a single cut and twist of the knife, with surprising rapidity and packed in dry salt, or smoked. The heading and evisceration are done by a single stroke, and an expert operator will prepare forty to fifty per minute. This work is done by negro women. In Washington a superior brand of smoked Alewives is prepared and sold as "Potomac Roe Herring." These are highly esteemed by judges of smoked fish, and command a price of three or four cents each in the city markets. They are equal to the finest Labrador Herring. Small quantities are prepared after the German fashion—*Bückling*.

In conclusion, we quote from Professor Baird's second report as Commissioner of Fisheries the following remarks upon the uses and importance of this fish:

"I am inclined to think, for various reasons, that too little has been done in our waters towards the restoration to their primitive abundance of the Alewife (*Pomolobus mediocris*), the Herring of our Southern and Middle States, not to be confounded with the sea Herring (*Clupea elongata*).

"The Alewife in many respects is superior, in commercial and economical value, to the Herring, being a much larger and sweeter fish, and more like the true Shad in this respect. Of all American fish none are so easily propagated as the Alewife, and waters from which it has been driven by the erection of impassable dams can be fully restocked in the course of a few years, simply by transporting a sufficient number of the mature fish taken at the mouth of the stream to a point above the dams, or placing them in ponds or lakes. Here they will spawn and return to the sea after a short interval, making their way over dams which carry any flow. The young Alewives, after a season, descend, and return, if not prevented, at the end of their period of immaturity, to the place where they were spawned.

"In addition to the value of the Alewife as an article of food, it is of much service in ponds and rivers as nutriment for trout, salmon, and other valuable fishes. The young derive their sustenance from minute crustaceans and other objects too diminutive for the larger fish, and in their great abundance are greedily devoured by the other species around them. In waters inhabited

by both pickerel and trout these fish find in the young Alewives sufficient food to prevent their preying upon each other. They are also, for the same reason, serviceable in ponds containing black bass.

"As a cheap and very abundant food for other fishes, the young Alewives can be placed in waters that have no connection with the sea by merely transferring from any convenient locality a sufficient number of the living mature parents, taken at the approach of the spawning season; they will remain for several months, and, indeed, can often be easily penned up by a suitable dam and kept throughout the year.

"It is in another still more important connection that we should consider the Alewife. It is well known that within the last thirty or forty years the fisheries of cod, haddock, and hake along our coast have measurably diminished, and in some places ceased entirely. Enough may be taken for local consumption, but localities which formerly furnished the material for an extensive commerce in dried fish have been entirely abandoned. Various causes have been assigned for this condition of things, and among others the alleged diminution of the sea Herring. After a careful consideration of the subject, however, I am strongly inclined to believe that it is due to the diminution, and in many instances to the extermination, of the Alewives. As already remarked, before the construction of dams in the tidal rivers the Alewife was found in incredible numbers along our coast, probably remaining not far from shore, excepting when moving up into the fresh water, and at any rate spending a considerable interval off the mouths of the rivers either at the time of their journey upward or on their return. The young, too, after returning from the ocean, usually swarmed in the same localities, and thus furnished for the larger species a bait such as is not supplied at present by any other fish, the sea Herring not excepted. We know that the Alewife is particularly attractive as a bait to other fishes, especially for cod and mackerel. Alewives enter the streams on the south coast of New England before the arrival of the bluefish; but the latter devote themselves with great assiduity to the capture of the young as they come out from their breeding ponds. The outlet of an alewife pond is always a capital place for the bluefish, and, as they come very near the shore in such localities, they can be caught there with the line by what is called 'heaving and hauling,' or throwing a squid from the shore and hauling it in with the utmost rapidity.

"The coincidence, at least, in the erection of the dams, and the enormous diminution in the number of the Alewives, and the decadence of the inshore cod fishery, is certainly very remarkable. It is probable, also, that the mackerel fisheries have suffered in the same way, as these fish find in the young Menhaden and Alewives an attractive bait.

"The same remarks as to the agency of the Alewife in attracting the deep-sea fishes to the shores, and especially near the mouths of rivers, apply in a proportional degree to the Shad and salmon."

177. ON THE OCCURRENCE OF THE BRANCH ALEWIFE IN CERTAIN LAKES OF NEW YORK.

By TARLETON H. BEAN.

The Branch Alewife, *C. vernalis*, Mitchill, has of late years attracted considerable attention in Cayuga and Seneca Lakes, New York, and in Lake Ontario. The United States National Museum has received a great many individuals from each of these lakes, and upon examination they were all found to be the species above named. This would be expected from the well-known habits of the Branch Alewife, which ascends far up the streams and pushes its way into the interior, while, on the other hand, its relative, the Glut Alewife, appears never to penetrate far beyond

the limits of tidal waters. The United States Commissioner has received many letters concerning this Alewife from persons living on the shores of Lake Ontario and in the vicinity of Lakes Cayuga and Seneca. Some thought that these fish were Shad; others, however, recognized the fact of their disagreement from that fish, and spoke of them as a species of Herring. It is noteworthy that the Alewife, so far as we know, did not appear in Lake Ontario until after the introduction of Shad into that lake by the Fish Commissioner of New York. We have been unable to obtain any evidence of its occurrence in that lake before the Shad was introduced. Again, Lakes Seneca and Cayuga are separated from Lake Ontario by obstructions which could not well be overcome by spawning fish. The only theory on which the fact of the presence of this fish in these New York lakes can be explained would appear to be either that young Herring have been introduced by the employés of the New York Fish Commission when instructed to place shad eggs in the lakes, or that young Herring have been taken out of the cans in the act of changing the water upon the shad spawn prior to their transportation to these waters. It is a significant fact that these broods of young Herring have been found only in the lakes in which Shad have been introduced.

We are in possession of information which seems to establish conclusively that the Alewife does not occur in the lower waters of the Saint Lawrence River, nor was there any evidence of its presence at Montreal until within the last nine years.

The name which is most universally applied to this species wherever it is known along the Saint Lawrence River is "Gaspereau." In the vicinity of Cayuga Lake it sometimes receives the name "Cayuga Lake Shad."

"The Alewife is known to exist in Lakes Seneca and Cayuga, and in Lake Ontario, specimens from all these waters being amongst the collections of the National Museum. It is said to occur also in the headwaters of the river Saint Lawrence, and the probability of its presence there is strengthened by the following extract from a communication to "Forest and Stream," August 13, 1878, by a gentleman who writes under the pseudonym "Piscator":

" . . . a lively little visitor which came to us in shoals a few weeks ago, and disappeared again. The visitor in question was a little, silvery fish, very similar to a Herring, but having its belly (as I found to my cost in taking it off my flies) serrated or edged with sharp spines. I presume it is the same fish which has appeared in such abundance in the Upper Saint Lawrence and Lake Ontario."

Mr. Fred Mather, in a letter dated July 22, 1878, says: "I have heard of their being taken with a fly at Quebec (where they are called Gaspereaux), and also above there on the Saint Lawrence."

They appear to be little known, however, in the Province of Quebec, for Mr. J. F. Whiteaves, of Montreal, in a letter dated July 26, 1878, writes: "So far as I know, the Gaspereau, or Alewife, is not found at all in the waters of the Province of Quebec. I have never seen a living or recently caught specimen."

SCARCITY OF ALEWIVES IN THE SAINT LAWRENCE.—Professor J. W. Dawson, writing from Little Metis, Province of Quebec, July 30, 1878, states as follows: "The species is quite abundant in the Northumberland Strait and the Bay de Chaleur and rivers entering these, but so far as I can learn rare in the river Saint Lawrence. . . . At this place (Metis, which you will find on the south side of the Saint Lawrence a little below Father Point), I am told that Gaspereaux are mere stragglers, appearing only very rarely and in small numbers; but that they are more plentiful at Matane, thirty miles farther east. I do not know of their occurrence on the north shore opposite this place, but have no positive information. I have never heard of the occurrence of the Gaspereau at Montreal, though the Shad ascends the river to that place, and far up the Ottawa."

The above extracts concerning the appearance of the Alewife in the Saint Lawrence tend to prove that, at least until a very recent period, it has been almost unknown in the lower waters of that river.

Specimens of the Alewife, obtained by Prof. S. F. Baird, from Croton River, Sing Sing, New York, are in the collections of the United States National Museum.

Prof. Hamilton L. Smith, Geneva, New York, furnishes the following information, obtained from an old angler, concerning the appearance of Alewives in the vicinity of Seneca Lake: "Their first appearance in the neighborhood of Seneca Lake was in the dam below the rapids at Waterloo, near Geneva, in June, 1868. In the spring of 1869 the surface of the water in the lake here was covered with them." The species was known in Cayuga Lake as early as 1868.

According to Mr. E. Tyler, of Henderson, New York, it was first noticed in Lake Ontario in June, 1873, when large quantities were taken in pounds and trap-nets.

Mr. W. Ainsworth, of Cape Vincent, New York, wrote on August 13, 1878: "This fish (the Alewife) first appeared in Lake Ontario and the river Saint Lawrence at Cape Vincent, in 1873, in large quantities."

THE ORIGIN OF THE ALEWIFE IN LAKE ONTARIO AND THE NEW YORK LAKES.—As already stated, there seems to be no reasonable doubt that the Branch Alewife was introduced into Lake Ontario with Shad, prior to whose introduction no evidence of its occurrence in that lake appears. It is an undecided point whether Alewives go down the Saint Lawrence to the ocean in the fall and return in the spring, as they do upon the Atlantic slope, or whether they spend the winter in the deeper waters of the lake. We have not the specimens at hand to enable us to establish the facts concerning the migrations of this species through the Saint Lawrence. It is noteworthy, however, that when they appear in the waters which they frequent, they come in immense schools, and at the time of, or a short time prior to, their spawning season. The first schools that appear seem to consist of large, adult fish. It may be that the schools descend the Saint Lawrence in the fall and ascend in spring. However this may be, we are justified in believing that Alewives were artificially introduced into Lake Ontario; and this is a more reasonable view of the case than to admit a total change in their habits, such as would be involved by their sudden departure from their accustomed waters into new and untried regions.

As to their presence in Cayuga and Seneca Lakes, New York, we have grounds for believing that they have, of their own accord, penetrated thus far into the interior of New York State. Mr. Fred. Mather writes that he has seen Alewives go up the canal locks at West Troy, and Prof. H. L. Smith, of Geneva, who first noticed them in the neighborhood of Seneca Lake in June, 1868, states that the canal was opened about that time, and thinks that they might have come into the New York lakes from the Chesapeake or Delaware Bays through Elmira and Painted Post.

We learn from Prof. Hamilton L. Smith that Alewives obtained near Geneva, New York, in June, 1868, were eight to nine inches long. He also sent to the National Museum specimens from Seneca Lake, four of which were, respectively, three and two-fifths, four and four-fifths, four and nine-tenths, and six and one-fifth inches in length. One specimen, forwarded by Prof. D. S. Jordan from Cayuga Lake, measured five and three-tenths inches. Two spent females, received from Horton Brothers & Ainsworth, and obtained by them in Lake Ontario, ranged from eight to nine and a half inches in length. Nearly all the specimens received from the interior lakes of New York are small—considerably smaller than those from Lake Ontario, and present a somewhat starved appearance. This characteristic was specially noticeable in the individuals which were found dead in immense numbers. The specimens from Lake Ontario are, on an average, equal in length to those which enter streams on the Atlantic coast. Mr. Ainsworth says that those cap-

tured at Cape Vincent vary in length from one and a quarter to eight inches. He never saw one that would weigh over half a pound. Mr. E. Tyler writes that the largest individuals are about nine inches long.

Reference has already been made, in another place, to the statement of Prof. H. L. Smith concerning the abundance of this fish in Seneca Lake, New York, near Geneva.

Mr. Ainsworth says that they were present at Cape Vincent in large shoals in 1873, and that they increased in numbers until, in 1878, immense quantities were taken throughout the waters of the lake and in the headwaters of the Saint Lawrence. He also states that he knew one fisherman to take fifteen barrels of Alewives from a small pound-net at one time. Mr. Tyler corroborates the statement of their abundance in June, 1873, and in a letter dated July 27, 1878, adds: "Now our waters are literally filled with them. In hauling seines they are often a terrible nuisance. Such countless millions are hauled ashore at times, that it becomes necessary to lift the seine and let them run out; it could never be got ashore with safety."

Messrs. Clark & Robbins, in a letter dated December 19, 1879, state that "they [Alewives] interfere with pound and trap net fishing, as they fill the nets to the exclusion of other fish."

Mr. George Burn, of the Exchange Bank of Canada, Montreal, says, in a letter dated August 20, 1878, that the Alewives come into the Saint Lawrence in great shoals at first, "the water being fairly alive with them."

MOVEMENTS.—It will be observed, from what has already been said, that the Branch Alewife is found in the waters under consideration, just as in the coast streams, at or near the surface of the water in immense schools. Mr. W. Ainsworth, in a letter previously quoted from, writes: "They swim in large schools and rise to the surface, and, when the water is still, they cause a ripple upon it similar to that produced by a school of mackerel."

Mr. George Burn, it will be remembered, has stated that in the Saint Lawrence River they appear in great shoals at first.

It would seem that the disappearance of the Alewife from these waters is as sudden as its appearance. Mr. E. Tyler, under date of September 1, 1878, remarks: "If possible for you to wait until October, I will be able to give you every grade from three inches in length to full-grown fish. The pound-nets at that time will be hauling, and barrels of them are taken at each haul. We can get the large ones at any time with cisco gill-nets." Mr. Tyler was, however, unable to secure specimens for us at the time when he supposed they would be abundant, and on January 20, 1879, he wrote: "We set to work every kind of device to get the Alewives. Our cisco fishermen could get none in their gill-nets here, and I went to Sacket's Harbor, a distance of nine miles, and made arrangements with the fish-dealers to notify all the pound-net fishermen to save some; but only one was caught in Chaumont Bay during the fall. I also went once, and sent twice, up the shore towards Oswego, seven miles, where an immense seine is hauled, and where, in the summer, these Alewives are so abundant that it is impossible to get the net ashore at times; I certainly thought I could not fail there; but only one was taken during the fall. Our cisco nets are often in one hundred feet of water, and no Alewives are gilled after the 1st of September.

Mr. George Burn has observed the sudden disappearance of the Alewife at Montreal, but he believes that they sometimes reappear after their first disappearance. It would seem from the above statements that different schools of Alewives are present at various times during the summer, and that all of them leave late in September or early in October. It seems also as if they go into the deeper water of the lake, and are sometimes caught in gill-nets. Mr. E. Tyler, writing from Henderson, New York, October 5, 1879, makes the following statement: "The

Alewives left us, as usual, about August 10, and the Shad also; at least none have been caught since."

In a letter dated June 14, 1879, he says: "Since about August 25 [1878] no Alewives were seen in these waters until the first of May last [1879]. . . . This spring [1879] I made arrangements with the owner of the seines (six miles south of Henderson) to send me the first ones taken, and he brought me five on May 14. . . . I drove over next day, but not one could be found in the net; but in a short time there was an abundance here, but all of one size. The first that came appeared to be large. . . . In answer to your question as to the route by which they come, I can only reply that the first seen of them was the last of April [1879]; the trout taken at the mouth of Saint Lawrence were filled with them. From the best information obtainable, they come here from the ocean with the Shad, and return with them in the fall to the same place."

Mr. W. Ainsworth, whom we have frequently quoted, writes that the spawning season for the Alewife in Lake Ontario is in June.

Mr. N. H. Lytle, of Ogdensburg, New York, wrote, September 26, 1879, concerning the Alewife as follows: "In June, 1878, a fisherman came into the 'Journal' office with several of these fish. He was not able to give them a name. I had frequently seen Shad on the butchers' stalls, and was of the opinion that they also were Shad. . . . I opened the fish and found them full of eggs and almost ready to spawn. A few days later they came up the Oswegatchie River in thousands as far as the dam, and many were caught by the boys. They were then from seven to ten inches in length. . . . This year they made their appearance again in the latter part of June, and came up the Oswegatchie River. They were noticed at many points on the Saint Lawrence and in Lake Ontario. Steamers passing up and down the river reported seeing them in schools of millions."

The following note was sent by a correspondent, "H. W. P.," at Waddington, May 31, 1878, to the Ogdensburg Journal, and forwarded to us by Mr. Lytle: "A colony of . . . Shad appeared here yesterday in full spawning order. John Stark caught thirteen, measuring eight inches and under." It is evident from the size of these fish and their spawning condition that *they must have been Alewives. Two large females, received from Horton Brothers & Ainsworth*, who collected them in Lake Ontario September 17, 1877, were spent.

ENEMIES AND FATALITIES.—According to the statements of persons living on the shores of Lake Ontario, Alewives are largely consumed by lake trout (*Salvelinus namaycush*), pike (*Esox lucius*), pickerel (*Esox reticulatus*), muskellunge (*Esox nobilior*), black bass (*Micropterus salmoides and M. dolomiei*). *There is no doubt that other predatory fishes destroy large numbers of the* Alewives, the wall-eyed pike (*Stizostedium*) and burbot (*Lota maculosa*) doubtless proving very destructive to this species. The yellow perch (*Perca americana*), species of *Lepomis*, *Ambloplites*, and other centrarchids doubtless kill vast numbers of the young.

According to the testimony of those who are familiar with the fisheries of the lakes, incredible numbers of Alewives are destroyed by the use of fishing implements intended for the capture of edible fish. Vast quantities of dead Alewives have been observed upon the shores of Seneca and other lakes of New York. Examples of such fish have been received by the United States National Museum from Seneca Lake, whence they were forwarded by Prof. Hamilton L. Smith. An examination of some of these specimens shows that the air-bladder is abnormally distended, filling the major portion of the abdominal cavity. What may have been the cause of this distension is of course unknown, but it will account for the presence of the dying fish at the surface.

Appended are two extracts (the one from the "Utica Herald" and the other from the "Rochester Union"), which may throw some light upon this subject:

"The cause [of the sudden death of vast numbers of fish] is the explosion of dynamite. Fishermen deposit crabs and other bait to attract particular species of fish, and when they [the fish] are supposed to be collected, they [the fishermen] drop a cartridge, charged with dynamite, to which is attached a fuse, and the explosion of which will kill every fish within a radius of sixty to eighty feet, and shock those at a greater distance, which, though they do not immediately rise to the surface, in their gasping, weakened condition, take into their gills the sand set free by the explosion, which ultimately produces death. By this means thousands of fish, not large enough for profitable sale or use, are destroyed; and, if the practice be continued, it will neutralize all efforts of our Fish Commission to stock our lakes and rivers. The quantity of black bass and other choice fish of Lake Erie and Niagara River daily exposed for sale in the fish markets has been and is suspicious, and led me to make diligent inquiry as to their mode of wholesale capture and destruction."

The second extract reads thus:

"Although 'Game Constable' Swartz succeeded in cleaning all the nets out of Irondiquoit Bay he has continued to observe that fish were brought from that locality and sold in larger quantities than could be taken in a legitimate manner. At an early hour this morning he set out for the Sea Breeze, arriving there about three o'clock. Nobody was seen fishing; but all along the shore of the sand-bar, about two hundred yards east of the Sea Breeze House, were found quantities of dead fish of all kinds, in some places piled three or four deep, and covering a considerable space of ground. These fish, consisting chiefly of bass, perch, bull heads, and sun-fish, were all small. On cutting open and examining a number of them, their air-bladders were found to have burst, as is always the case when fish are killed by means of nitro-glycerine cartridges exploded in the water. The conclusion is, therefore, irresistible that the fish were killed in this way. When they come to the surface they are all scooped up and taken ashore, where the big ones are sorted out, and the little ones left on the sand. The deadly explosive kills every living thing, old and young, within reach of it."

CAPTURE.—Specimens have been dredged, by Prof. B. G. Wilder, in Cayuga Lake. Vast numbers, too, are taken about the foot of Lake Ontario in pounds, traps, and seines. Small numbers are caught in gill-nets, even in the cisco nets, which are set in very deep water. Mr. E. Tyler writes that at Henderson, New York, Alewives take a fly quite readily. Mr. Fred. Mather writes that he has heard of their having been taken with a fly at and above Quebec on the Saint Lawrence. Mr. George Burn, of Montreal, states that he has caught Alewives with artificial flies at that place.

Inquiries have been made as to the methods of utilizing Alewives as the basis of fertilizers, but we do not know that anything has yet been attempted in that direction. Mr. W. Ainsworth writes under date of August 13, 1878, as follows: "They furnish excellent food for salmon, trout, pike, pickerel, and black bass. They have increased the quantity, as well as improved the quality of these fish."

Mr. E. Tyler wrote on July 27, 1878: "So far I consider them a blessing. They supply all our edible fishes with an abundance of food, so that the young fry of bass, trout, pike, pickerel, and muskellunge are not destroyed as formerly, but are allowed to mature, and to-day all the above fishes are more plentiful than for many years past."

There can be no doubt that the Alewife would prove useful as food and bait for other fishes. The annoyance which it causes by filling the seines and pounds will, undoubtedly, be offset by its usefulness in the fisheries of the future.

178. THE INLAND ALEWIFE OR SKIPJACK—CLUPEA CHRYSOCHLORIS.

This fish, which is found in many parts of the Mississippi Valley, has recently been found by Mr. Silas Stearns in the salt water off Pensacola—a surprising circumstance, since the species was thought to be an inhabitant of fresh water exclusively. "It is known to most inland fishermen as the 'Skipjack,'" writes Professor Jordan, "in allusion to its habit of leaping from the water. It is also sometimes called 'Shad' and 'Herring.' It is abundant throughout the Mississippi Valley in all the larger streams. In the neighborhood of the ocean it descends to the Gulf, but in the upper courses it is permanently resident. It has also entered Lake Michigan and Lake Erie since the construction of the canals. It reaches a length of a little more than a foot. It feeds on small crustaceans, worms, and the like, rarely taking the hook. As a food-fish it is regarded as wholly worthless, its flesh being poor and dry, and full of innumerable small bones."

179. THE SHAD—CLUPEA SAPIDISSIMA.

By MARSHALL MCDONALD.

NAMES.—The following notes on the names of the Shad are taken from an unpublished manuscript by Mr. Goode upon the fisheries of Florida. The Shad appears to have been considered by early American writers on fish identical with the Shad of England, *Clupea finta*. The first to give to it a distinctive name was Alexander Wilson in the American edition of Rees' Cyclopædia.[1] I quote his description in full, since it was claimed by Rafinesque, whose remark has been since frequently quoted, that *Clupea sapidissima* was "catalogued, not described," by Wilson:

"*Clupea sapidissima* (AMERICAN SHAD).—No spots on the sides; snout entire (not bifid as in the European); from eighteen inches to two and a half feet in length; weighs from six to ten and twelve pounds. Scales large, deciduous, and of a silver color, most delicious. They are for six months about the capes or mouths of large rivers, then run into the sea. During March, April, and May, they ascend these rivers to the freshes, and thence toward their sources, in order to deposit their eggs in shallow water, where, hatching, the young fry descends in the latter part of the summer and autumn to the tide waters, and thence down to the salts; and the adults return likewise to the sea, thin, emaciated, and weak."

GEOGRAPHICAL DISTRIBUTION.—The Shad is found along the whole Atlantic coast of the United States, and its capture constitutes one of the most important fisheries in all the streams draining into the Atlantic between the Gulf of Saint Lawrence and the Saint John's River, Florida. Its northern limit is thus defined by Charles Lanman in the "Report of the United States Fish Commission," part ii:[2]

"The Shad is but rarely seen on the Atlantic coast of Nova Scotia. It is found in the Gulf of Saint Lawrence, the various rivers of which it ascends as far north as the Miramichi, which seems to be its limit in that direction, none having been seen in the Bay of Chaleur."

Throughout this entire range the Shad is found in sufficient quantities to give rise to fisheries of great commercial value. There is no run of Shad into any of the rivers draining into the Gulf of Mexico, although the capture of isolated individuals of this species has been reported from the

[1] The Cyclopedia or Universal Dictionary of Arts, Science and Literature. By Abraham Rees . . . First American edition in forty-one volumes. Philadelphia. [The American edition is said by Allibone to have been in course of publication from 1809 to 1820. Dr. Gill tells me that he has evidence to show that vol. ix was published prior to 1814.]

[2] Page 461.

Alabama River and from several tributaries of the Mississippi prior to any steps towards the artificial propagation of Shad in these waters by the United States Fish Commission. It is, however, probable that many of the so-called "White" Shad were but large specimens of the "Golden" Shad of the Mississippi Basin. Unquestionably, however, Professor Baird was referring to the capture of a genuine *Clupea sapidissima* in the waters tributary to the Gulf of Mexico when he wrote:[1] "I have already referred to the discovery of Shad in the Alabama River, whether the result of Dr. Daniel's experiments already detailed or not; and I am assured by reliable testimony that they are found at the present time in other streams of Alabama. Of this I am well satisfied, having actually received a specimen from Mr. W. Penn Yonge, of Springville, Alabama, taken at Elba, Alabama, and preserved in alcohol, and distinguishable in not the slightest particular from the Shad of the eastern coast. I have also the assurance of Dr. Lawrence of their capture at the Hot Springs of the Ouachita; of Dr. Middleton Goldsmith, at the Falls of the Ohio, near Louisville; and of Dr. Turner, in the Wabash River of Indiana and Illinois, and in the Neosho River of Kansas."

If the occasional presence of individuals of this species in the waters tributary to the Gulf of Mexico be admitted, it seems unaccountable that, since no fisheries have there been established for its capture, that the natural increase should not have been such as to cause at least as abundant a run into the rivers emptying into the Gulf as into those on the Atlantic coast.

If, moreover, assuming that this species has been present in these waters in sufficient numbers for effective reproduction, natural causes have not combined to establish a run of this fish in the tributaries of the Gulf, it can scarcely be hoped that any measures of artificial reproduction would, if resorted to, accomplish the desired result. Nor does existing proof appear sufficiently positive, as yet, to establish more than the occasional occurrence of isolated specimens in these waters under conditions simply natural. It is probable that where true Shad have been found in the tributaries of the Gulf of Mexico explanation may thus be made: Occasional individuals have strayed beyond their natural geographical range, around the Florida peninsula, and, once in the Gulf, they have entered the rivers under the impulse of reproduction, but never in sufficient quantities to maintain themselves.

In January, 1879, by direction of Prof. G. B. Goode, the writer was requested to proceed to the Alabama River to investigate the question of the natural occurrence that White Shad in this river. The report then made gives probably all the facts on this subject that have yet been obtained. They are as follows:

"There is no doubt that 'White Shad,' to the number of two or three thousand, were taken in the Alabama River and its principal tributary, the Coosa, in the seasons of 1878 and 1879, and of inferior size and in smaller numbers in the season of 1877. Whether these runs of Shad were the result entirely of the government 'plants,' beginning in 1875, or were due in part to previous plants made by individual enterprise, are the questions to the solution of which I have directed my investigation. I have not sought to determine the question whether the 'White Shad,' *Clupea sapidissima*, is indigenous to the Alabama River. This has been stated again and again. Judge Phelan, in a letter to the 'Montgomery Advertiser' of April 11, 1878, claims to have eaten 'White Shad' at Centreville, Alabama, not later than 1848. They were taken in traps at the Falls of the Cahaba, and were pronounced 'White Shad' by Mr. Samuel Jamison, an old North Carolina fisherman. Judge Phelan further states that some claimed that they were only Hickory Shad.

"No amount of such evidence can ever settle this question. There is always the possibility

[1] Report United States Fish Commission, part ii, p. 55.

of mistake on the part of those making the assertion, and since the presumed or actual introduction of Shad into these waters, we cannot settle the question by actual identification of specimens.

"If the true *Clupea sapidissima* is natural to the waters of the Alabama, or if the plants in the Coosa in 1848, and the plant in Conley Creek, near Montgomery, in 1856, were successful, then there must exist in the waters of the Alabama certain conditions which are unfavorable to natural increase, and all the efforts of the United States Commission to establish an annual run of Shad in the Alabama River by artificial plantings will prove abortive.

"On the other hand, if the planting operations of the United States Commission are successful in establishing a run of Shad in this river, the result will prove that the Shad are not indigenous to these waters and that previous plants were unsuccessful. Two or three years will settle this question.

"There seems to be nothing in the conditions presented by the Alabama River to prevent the establishment of a run of Shad in that river, unless the low temperature of the river during the running season of the fish prevents maturity of the ova."

The geographical range of the Shad, as already stated, was confined to the Atlantic coast of the United States until, by the operations of the United States Fish Commission, its limits were vastly extended. Runs of Shad, sufficiently large to be of commercial value, have been established in several of the tributaries of the Mississippi River, notably the Ohio River; and the *several plants made from time to time in the Sacramento River, on the Pacific coast, have resulted* in the colonization of this species in all the rivers of the Pacific slope, from the Sacramento to *Puget Sound*.

MIGRATIONS.—It is doubtful whether there is any general coastwise movement of the Shad. *That there is an occasional migration of this kind is evidenced by the following facts:* The Shad of the rivers of the South Atlantic coast, as a rule, have black-tipped caudal and dorsal fins, *which distinctive marks of coloration are absent in the Shad of more northern rivers;* and yet occasionally these southern Shad are caught as far north as the tributaries of the Chesapeake and Delaware Bays. *These fish have undoubtedly been born and bred in southern* waters, and their appearance so far north would indicate that occasionally this southern variety *strays beyond its normal range.*[1] *At one time*[2] *it was imagined that the whole body of American* Shad, having wintered in the south, started northward with the new year, and as each river mouth was reached a detachment would leave the entire mass for the purpose of ascending the river, the last remaining portion of the immense school entering the Gulf of Saint Lawrence.

At a later date it was thought more reasonable to suppose that the young fish, hatched out in any particular stream, went out into the sea and remained within a moderate distance of the coast *until the period again occurred for their upward river migration.* Their appearance, first in the extreme southern river of the coast, the Saint John's, and at later dates successively in the more *northern rivers, was thought to confirm this view. It will be seen, in the discussion of the* relation of the movements of the Shad to the water temperature, that this order of appearance when preserved may be reasonably accounted for; there are, however, exceptions. For instance, the Edisto River is many miles north of the Savannah, and yet the run of Shad in the former is usually coincident with that in the latter. This leads us to believe that the Shad are generally distributed along the coast at all times, entering the rivers as soon as the temperature of the

[1] Report United States Fish Commission, part ii, p. 48.

[2] *It may here be mentioned that there are probably several well-defined hydrographical areas along the Atlantic coast beyond each of which Shad indigenous to that area rarely stray. Each race has its own peculiar characteristics.*

water is suitable. It is but natural that the waters of a creek or short stream, not having its source in the mountains, should in the spring become warm long before those of a large river whose headwaters are far up among the mountains; for which reason we may expect to find, in the case of two rivers, the most southerly of which has a longer water-course than the other, that the Shad will first enter the more northerly, yet shorter, and consequently, at a given date, warmer stream. The question, therefore, appears to be rather one of temperature than of geographical location.

The greater portion of the life of the Shad being spent in salt water, the possibility of close observation as to their food, habits, or precise habitat is precluded. The young fry, hatched out in the rivers in spring and early summer, remain there until the following fall, when, the temperature of the waters having fallen below 60°, they leave for the ocean. Nothing more is seen of them until they return to the rivers as mature fish for the purpose of spawning. In these upward migrations the schools of mature fish ascend the rivers either until obstructed by impassable falls or dams, or until the volume of water becomes very inconsiderable. Before artificial impediments were placed in the rivers, the limit of this movement was the natural and insurmountable falls to be found at the head of almost all of our principal streams. For example, in the Savannah River the Shad used to ascend to the Falls of Tallula, at the very source of the river in the northern part of Georgia. In the Potomac they ascend as high as the Great Falls. In the Susquehanna River, in which there exist no natural obstructions, their migrations extended up into the State of New York, a distance of several hundred miles above the present limit. On the Hudson River they ascended to Glens Falls. On the Connecticut at one time they went as high as Bellows Falls, but recent obstructions in this river have materially reduced the extent of their range.

The present limit of the upward movement of the Shad in our rivers, the natural limit before obstructions were interposed, and the extension of the natural limit which may be obtained by overcoming these natural and artificial obstructions now existing, are shown in the accompanying chart. It will be seen from this that the breeding area has been diminished from one-half to one-fourth its original extent, involving a corresponding reduction in the productive capacity of these streams.[1]

HEREDITARY INSTINCT OF LOCALITY.—The annual migration of the Shad in the spring of the year into the fresh waters of our rivers has been explained by various theories. In regard to the salmon, which has been long known and observed in European waters, the fact seems to have been established that the same individual will return year after year to the same stream for the purpose of spawning, and that young fish bred in a certain stream usually come back to the same upon their return from the ocean as mature fish. This habit has not been conclusively established in regard to any other family of anadromous fishes, but it is generally believed that all salt-water species which spawn in fresh water return for this purpose to those streams in which they themselves were deposited. An examination of the literature of fish culture will make it evident that this opinion has been held very generally, and, indeed, has furnished to a great extent the argument for the prosecution of the work of artificial reproduction. It is a common belief, too, among fish-culturists that the mature individuals of all anadromous species, including the Shad, are led back to the waters in which they were spawned by a conscious wish on their part to return to those very localities in which they spent their young life. Important exceptions to this rule are, however,

[1] See Chart of the River Basins of the Atlantic Slope.

well established by recent observations. For instance, it is well established that the runs of Shad into the Susquehanna and Potomac Rivers are characterized by alternations of abundance; that is to say, an excessively large yield for any given season in the one involves a corresponding diminution in the yield for the same season in the other, thus precluding the possibility of each individual returning annually to its native stream. Again, it was confidently expected that all the young Atlantic Shad which were transferred to and planted in the Sacramento River would, on their return from the Pacific Ocean as mature fish, find their way back to this stream. This was not, however, the case, for, to the utter astonishment of many fish-culturists, a considerable number of these now mature fish made their appearance in many streams of the Pacific lying far north of the Sacramento River—streams to which Shad had never been indigenous and in which none had ever been planted.

These facts go a long way to disprove the theory of instinct of locality, and indicate that the river movements of the Shad are regulated by involuntary and extraneous influences. The migration and colonization of this fish northward along the Pacific coast has been so general that at the present day new generations of a single plant are found in every stream on the Pacific from the Sacramento River to Puget Sound.

THE "FEEL" OF THE RIVERS.—Some writers, notably Mr. Charles G. Atkins, have suggested the idea that the upward river migration of the anadromous fishes is directed by an instinct which impels them to swim against the current. It is supposed by him that in their coastwise movement the Shad, when opposite the mouths of the rivers, feel the outflowing current and, responding to the invitation, immediately turn to and stem it and are thus led into and up the stream. The conclusive reply to this supposition is that in the wide estuaries of our North Atlantic streams there is no sensible current, excepting that produced by the tidal ebb and flow, which is far too indeterminate to be the directing cause of the migrations of those vast schools of Shad, Alewives, and other species which annually enter our rivers. Even if the fish were attracted up stream by the gratification of that presumed impulse or desire to swim against the current, how can we account for their migration down stream, at the appropriate season, this movement being as regular and as universal as the upward migration?

CHANGE OF SALINITY.—It has been suggested that Shad may be sensible of the decreasing salinity of the water as they enter and ascend the rivers, and that they may be led into continental waters in order to enjoy a more congenial habitat; but in this event it is necessary to explain why they do not remain in the rivers altogether.

WATER TEMPERATURES.—Prior to the last decade, very little attention was paid to the water temperatures in connection with the migrations of fish. We have on record but few series of observations of water temperature during the season of our river fisheries. Since the inauguration of the United States Fish Commission, however, and the establishment of hatching stations on the rivers, it has become possible to make a closer study of this subject. It will, however, require a connected series of such observations, made during several seasons and at many stations, in order to obtain sufficient data for a satisfactory discussion of "the relation of the movements of fish to the water temperatures." Up to the present time the drift of investigation goes to prove that the movements of fish, anadromous and otherwise, are controlled largely, if not entirely, by the temperature of the medium in which they live.

In the case of "bottom-feeders," their movements are dependent, no doubt, principally upon the

migrations of their prey; but here again it is probable that the movements of the latter are influenced by temperature.

In the case of Menhaden and Shad, which species feed as they swim, the temperature of the water is probably the main factor in determining their movements. It is a fact, for example, that the disappearance of Menhaden from the coast of Maine[1] was, and has each year since been, coincident with a uniformly lower temperature of the water along that coast during the menhaden season.

The causal relations of the migrations of the sea Herring to water temperatures is a matter recognized by the pisciculturists and fishermen of the North European Atlantic region; but their observations, as with our Shad, have not been sufficiently extensive to enable them to define accurately the relations of the one to the other.

In regard to the Shad, and presumptively to other fishes also, it is believed to be true that there is a certain temperature of the water in which these fish prefer to live; in other words, that they aim to occupy a hydrothermal area of certain temperature; and, further, that their migrations are determined by the shifting of this area.

To state this theory somewhat differently, it is believed that all migratory fish have a normal range of temperature in which they seek to remain. As before stated, observations on this point are not as yet extensive, and therefore the limiting hydro-isothermals within which a given species may at any time be found cannot yet be absolutely defined.

So far as this matter has been examined with regard to the Shad, the following conclusion has been reached, namely, that they occupy an hydro-isothermal belt, or area, limited by the temperature of 60° F. to 70° F.; that they move with this belt, *i. e.*, as the season advances, into and up the rivers. This movement, at least in the case of the Shad and Herring, takes place at the time when they have nearly matured their spawn, and just at that important crisis, by means of that exact balance and adjustment which nature everywhere provides, the fish are brought by influences of which they are entirely unconscious into such relations and under such conditions as make reproduction possible. But, although the operation of spawning is mainly that for which the fitness of relations and conditions has been ordained, the following statements will show that the fish in moving up the rivers are not always actuated by the immediate desire to deposit their spawn.

OBSERVATIONS ON THE SAINT JOHN'S RIVER, FLORIDA.—In the Saint John's River, Florida, the Shad appear in the river several months before the spawning time, and, although this season in the Upper Saint John's is not largely in advance of the same season in rivers as far north as certain tributaries of the Chesapeake, yet by reason of their early presence in the Saint John's the shad fisheries, as has before been noted, are there prosecuted during the entire winter. They do not enter the river at this time for the purpose of spawning. By reference to tables giving the temperatures of the Saint John's River at Jacksonville for twelve months beginning March 1, 1877, and ending February 28, 1878, it will be seen that in the Saint John's River the temperature of the water gradually descends, reaching 60° F. at Jacksonville about the last of November. This date is coincident with the first appearance of Shad in the Saint John's.

[1] This commenced in 1879, and they have not yet reappeared to any extent.

Table of temperatures, Saint John's River, Jacksonville, Florida.

RECORD OF DAILY OBSERVATIONS TAKEN AT 3 P.M.

[Data furnished by Prof. G. Brown Goode.]

Date.	Location of thermometer.			Date.	Location of thermometer.			Date.	Location of thermometer.		
	Air.	Surface.	Bottom.		Air.	Surface.	Bottom.		Air.	Surface.	Bottom.
1877.	° F.	° F.	° F.	1877.	° F.	° F.	° F.	1877.	° F.	° F.	° F.
Mar. 1	60	60	60	May 1	71	69	69	July 1	90	83	83
2	61	61	61	2	76	68	68	2	92	84	83.5
3	70	62	61.5	3	81	69	68	3	90	85	85
4	76	62	62	4	80	70	69	4	95	85	85
5	78	65	64	5	86	70	70	5	89	85	85
6	54	62	62	6	84	72	71	6	90	84	83
7	70	64	63	7	83	71	70	7	85	82	82
8	76.3	64	64	8	77	70	70	8	83	81	81.5
9	73	64	64	9	76	71	70	9	87	82	82
10	51	64	64	10	80	73	72	10	83	83	83
11	61	63	63	11	75	70	70	11	85	83	82.5
12	74	65	64	12	74	70	70	12	85	80	80
13	78	66	66	13	80	71	70	13	87	82	81
14	72	65	64	14	79	71	70	14	89	82	82
15	69	65	64	15	78	70	70	15	89	81	81
16	72	66	65	16	77	70	70	16	88	80	80
17	77	66	65	17	75	70	70	17	87	82	81
18	61	65	65	18	74	70	70	18	90	82	82
19	70	64	63	19	80	70	70	19	90	82	82
20	74	62	61	20	82	71	71	20	81	79	79
21	73	62	62	21	84	75	75	21	84	81	80
22	63	62	61	22	91	76	76	22	80	81	81
23	69	62	62	23	95	77	77	23	87	82	81
24	72	62	62	24	78	76	76	24	89	82	81
25	67	63	63	25	82	76	76	25	88	82	82
26	54	59	59	26	74	74	74	26	91	82	82
27	75	58	57	27	72	71	71	27	91	84	84
28	81	59	57	28	67	69	70	28	92	84	84
29	67	60	59	29	73	69	68	29	97	85	84
30	66	60	60	30	78	70	69	30	98	84	84
31	77	60	60	31	79	70	70	31	87	84	84
Apr. 1	71	61	60	June 1	80	71	70	Aug. 1	86	83	82
2	78	62	61	2	81	72	72	2	85	82	82
3	75	63	62	3	84	75	74	3	90	83	83
4	79	64	63	4	89	77	76	4	90	83	83
5	78	64	63	5	89	77	77	5	90	85	85
6	79	66	66	6	86	76	75	6	92	87	87
7	84	68	67	7	95	78	78	7	95	86	86
8	76	64	64	8	94	78	78	8	92	86	86
9	75	66	65	9	80	80	80	9	91	83	83
10	62	64	55	10	87	80	79	10	94	83	83
11	62	63	63	11	77	79	79	11	90	84	84
12	68	63	63	12	77	77	77	12	90	83	83
13	71	64	64	13	81	76	76	13	92	84	83
14	61	60	60	14	81	75	76	14	81	83	83
15	67	61	61	15	85	78	77	15	87	82	82
16	74	62	61	16	84	78	78	16	92	83	82
17	77	64	62	17	86	78	78	17	88	83	83
18	81	64	63	18	88	79	79	18	78	79	79
19	79	65	64	19	95	83	82	19	81	79	79
20	84	66	66	20	80	83	83	20	83	79	79
21	80	68	67	21	84	84	84	21	84	80	80
22	74	67	66	22	87	83	82	22	78	79	79
23	76	68	67	23	90	82	81	23	81	79	79
24	84	70	69	24	90	81	81	24	87	80	80
25	84	72	71	25	95	84	84	25	80	79	79
26	79	69	69	26	97	85	85	26	82	78	78
27	85	70	70	27	98	85	85	27	86	79	78
28	83	70	70	28	97	85	85	28	85	79	78
29	78	70	69	29	88	85	85	29	87	79	78
30	75	69	69	30	89	84	84	30	90	80	79
								31	90	80	80

EXTREME AND MEAN TEMPERATURES, BY MONTHS.

	Air.	Surface.	Bottom.		Air.	Surface.	Bottom.
	° F.	° F.	° F.		° F.	° F.	° F.
March:				June:			
Maximum	81.0	66.0	66.0	Maximum	98.0	85.0	85.0
Minimum	51.0	58.0	57.0	Minimum	77.0	71.0	70.0
Mean	69.1	62.6	62.2	Mean	87.4	79.4	79.2
April:				July:			
Maximum	85.0	72.0	71.0	Maximum	96.0	85.0	85.0
Minimum	61.0	60.0	60.0	Minimum	81.0	79.0	79.0
Mean	76.0	65.7	65.1	Mean	87.0	82.5	82.4
May:				August:			
Maximum	95.0	77.0	77.0	Maximum	95.0	87.0	87.0
Minimum	71.0	68.0	68.0	Minimum	81.0	79.0	78.0
Mean	78.7	74.3	71.0	Mean	87.0	81.7	81.4

Table of temperatures, Saint John's River, Jacksonville, Florida—Continued

RECORD OF DAILY OBSERVATIONS TAKEN AT 3 P. M.

[Data furnished by Prof. G. Brown Goode.]

Date.	Location of thermometer.			Date.	Location of thermometer.			Date.	Location of thermometer.		
	Air.	Surface.	Bottom.		Air.	Surface.	Bottom.		Air.	Surface.	Bottom.
1877.	°F.	°F.	°F.	1877.	° F.	° F.	° F.	1878.	° F.	° F.	° F.
Sept. 1	94	82	81	Nov. 1	80	71	71	Jan. 1	56	56	56
2	90	80	80	2	83	71	71	2	58	55.5	55
3	83	80	80	3	68	70	70	3	60	56	56
4	85	80	80	4	73	69	69	4	58	56	56
5	88	80	80	5	78	69	69	5	48	54	54
6	90	81	81	6	67	68	68	6	48	52	51.5
7	83	82	81	7	71	68	68	7	48	52	52
8	80	81	80	8	75	68	68	8	48	52	52
9	86	81	80	9	66	67	67	9	62	52	51.5
10	85	81	81	10	58	64	64	10	52	52	51.5
11	88	81	81	11	59	62	61	11	60	52	51
12	93	82	82	12	63	61	60	12	60	52	51
13	91	82	82	13	68	60	59.5	13	70	53	53
14	84	80	80	14	73	61	61	14	60	53	53
15	85	81	81	15	70	61	61	15	51	52	52
16	89	82	81	16	75	63	62	16	54	52	52
17	90	82	82	17	76	63	63	17	59	53	52
18	86	82	82	18	73	63	63	18	63	54	53
19	88	82	82	19	71	63	63	19	70	55	54
20	90	82	82	20	70	63	63	20	73	56	56
21	88	81	81	21	72	63	63	21	67	56	56
22	88	81	81	22	64	62	62	22	62	56	56
23	80	81	81	23	63	62	62	23	62	56	56
24	82	79	79	24	64	61	61	24	65	51	56
25	81	78	77.5	25	67	60	60	25	66	56	56
26	75	77	77	26	67	60	60	26	67	57	56
27	78	77	77	27	73	60	60	27	71	58	58
28	81	76	75	28	64	60	60	28	65	58	58
29	80	75	75	29	57	59	59	29	63	58	58
30	73	74	74	30	46	56	56	30	65	59	59
Oct. 1	78	74	74	Dec. 1	51	54	54	31	61	59	58.5
2	80	74	74	2	51	52	52	Feb. 1	62	58	58
3	80	74	74	3	66	52	52	2	72	59	59
4	81	73	72.5	4	65	53	52	3	56	58	57.5
5	72	71	71	5	65	52	52	4	59	57	57
6	70	70	71	6	50	51	51	5	52	56	56
7	71	70	70	7	54	51	51	6	56	56	56
8	84	71	70	8				7	71	58	57
9	76	70	70	9				8	71	58	58
10	78	70	70	10				9	67	58	57
11	79	70	70	11				10	65	58	57
12	77	70	70	12				11	55	57	57
13	76	70	70	13				12	52	56	55
14	78	70	70	14				13	61	55.5	55
15	77	70	70	15				14	70	57	56
16	77	70	70	16				15	68	57	57
17	80	71	71	17				16	62	58	58
18	80	71	71	18				17	69	58	58
19	83	72	71	19	60	58	58	18	69	58	58
20	81	72	72	20	62	58	58	19	61	58	58
21	77	71	71	21	71	60	60	20	67	59	59
22	69	70	70	22	71	61	61	21	68	59	59
23	72	70	70	23	69	61	60.5	22	72	60	60
24	71	70	70	24	71	61	61	23	66	61	61
25	84	70	70	25	73	61	61	24	71	63	63
26	79	70	70	26	64	61	61	25	63	61	61
27	77	70	70	27	63	61	61	26	55	60	60
28	79	70	69	28	62	61	61	27	55	59	59
29	80	70	69	29	67	61	61	28	67	60.5	59.5
30	82	71	71	30	55	61	61				
31	79	71	70.5	31	52	57	56.5				

EXTREME AND MEAN TEMPERATURES, BY MONTHS—Continued.

	Air.	Surface.	Bottom.		Air.	Surface.	Bottom.
	° F.	° F.	° F.		° F.	° F.	° F.
September:				December:			
Maximum	94.0	82.0	82.0	Maximum	73.0	61.0	61.0
Minimum	73.0	74.0	74.0	Minimum	51.0	51.0	51.0
Mean	85.2	80.1	79.9	Mean	62.1	57.4	57.3
October:				January:			
Maximum	84.0	74.0	74.0	Maximum	73.0	59.0	59.0
Minimum	70.0	70.0	69.0	Minimum	48.0	52.0	51.0
Mean	77.7	70.8	70.7	Mean	60.4	54.8	54.5
November:				February:			
Maximum	83.0	71.0	71.0	Maximum	72.0	63.0	63.0
Minimum	46.0	56.0	56.0	Minimum	50.0	55.5	55.0
Mean	68.4	62.6	63.5	Mean	63.3	46.3	58.0

Now, in all other streams on the Atlantic coast, the fish appear to wait until the temperature of the river has risen above that of the salt-water area into which the river empties, before they ascend in the spring. The migration of the Shad into the Saint John's River is clearly not for the immediate purpose of spawning, as that operation is not performed for months, but in order that they may keep within the limits of the hydro-isothermal area appropriate to them. We must suppose that the temperature of the ocean waters, on the continental plateau outside the coast line, is higher than 60° F., and although uncongenial to the fish, yet they must necessarily remain in that temperature until the waters of the Saint John's, cooling as winter advances, have fallen below the temperature of the outside waters. As soon, therefore, as water of a lower temperature than that in which they are commingles with the ocean water, it serves as an incentive—as it were the signal—for their migration into the estuary of the Saint John's.

OBSERVATIONS ON THE POTOMAC RIVER IN 1881.—In 1881 the writer, then in charge of the shad-hatching operations on the Potomac River, collected full statistics of the catch of Shad and Alewives from four of the seine fisheries occupying that section of the river lying between Indian Head and Mount Vernon. From these statistics the fluctuations in the run of the Shad up the river have been closely approximated, and at the close of this paragraph general deductions relative to the same will be made. Through the courtesy of the Light-House Board and the United States Signal Office, observations on the water temperature at Winter Quarter Shoals and at Norfolk, Virginia, have been obtained. The former point is a light-house in the Atlantic, lying about fifteen miles from the Virginia coast, and situated, it is believed, on the inner edge of the cold arctic current that flows down the coast inside of the Gulf Stream. The observations taken there represent the temperature of the water on the continental plateau between Cape Charles and Cape Henry. The records taken at Norfolk serve as an index of the temperature of the waters of the Chesapeake Bay, but are subject to inaccuracies, Elizabeth River being hardly more than a tidal estuary, and the temperature of its waters being influenced very materially by local meteorological conditions.

A graphical representation of the temperatures at these two points, as also of the corresponding temperatures at the Potomac hatching station, is given in the accompanying diagram, which serves to illustrate the influence of hydrothermals in determining the direction of the movements of the Shad and Alewives and in limiting their range. In the diagram are also presented the fluctuations of the run of these fish in the fishing season, as deduced from the records of "catch," furnished by the four seine fisheries already alluded to.[1]

By reference to the diagram it will be seen that during the first seventeen days of April (1) the temperature of the water in the Potomac was occasionally lower than at Winter Quarter Shoals during the same period of time; (2) that the water of the Chesapeake Bay was warmer than that of the ocean between Cape Charles and Cape Henry, and also warmer than the water in the Potomac River, and that (3) during that time the temperature was in none of those waters above 50° F. As soon as with the advancing season the water in the river became warmer than in the bay the Shad commenced to ascend the Potomac, and when the temperature of the river rose to 60° F. the upward run attained its maximum; the main body of Shad and Herring ascended the river when its temperature ranged from 56° F. to 66° F.; and, further, that when the temperature of the river passed above 66° F. the run of Shad and Herring rapidly diminished. It may be seen also that in general the fluctuations in the run of the Herring closely followed that of the

[1] Although the data obtained from those four shores do not by any means represent the total catch for the whole river, yet, covering as they do a complete section of the river, they furnish figures from which the fluctuations in the upward migrations of the Shad and Alewife for the whole river can be approximated.

Shad. The run of Alewives indicated by the diagram in the early part of the season at low temperature was undoubtedly *C. vernalis*, or the Branch Herring, which makes its run on a temperature several degrees lower than suitable to the Shad or the Glut Herring. The fact that the Shad commence running into the Potomac when the temperature of the river is 56° F. or less, does not antagonize the theory here stated, that the hydro-isothermal area which they prefer to occupy is that having the temperature of about 60° F. If, as is probably the case, there is oceanwards a limiting wall of low temperature for the Shad occupying the Chesapeake area,[1] then at all seasons of the year the Shad must be found at some point within that area, be the temperature exactly what they prefer or not. In other words, the Shad in their migrations travel on temperature paths, the direction being always towards 60° F.

Shad ready to deposit their spawn seem to prefer waters of a warmer temperature than 60° F. Therefore, when the mature Shad, intent on reproduction, leave the hydrothermal area of 60° F. and ascend the rivers into waters of 65° F. to 70° F. and upwards, they are unaccompanied by the half-grown Shad, the latter ceasing to ascend as soon as they encounter a temperature of more than 60° F. In 1882, however, when the temperature of the water was below 60° F. for the greater portion of the season, the spawning had to take place in water colder than the fish would have preferred, and therefore mature and young Shad were found together on the spawning grounds.

Observations made during that season show that large numbers of young Shad were taken, which would not have been the case had the temperature of the river waters risen above 60° F. Inasmuch as the fishing operations are conducted with a view to obtain mature fish, and in most years the young do not accompany the full-grown fish up to the fishing grounds, it would certainly appear as though this was a special provision of nature to secure the continuance of the species, providing against the capture of the young Shad during the fishing season.

Observations on the movements of young Shad in the Potomac.—The young Shad which are hatched out during May and June remain in their native streams until the temperature of the water falls below 60° F. They then move down the rivers as the temperature falls, passing into the salt water as soon as the cooler weather has reduced the river temperature below the degree congenial to them, and, as a rule, return no more to the fresh waters until they are full-grown fish. This statement is borne out by observations made in 1881 by Mr. W. E. Stuart and Mr. Gwynn Harris, inspectors of marine products. These gentlemen, who have been largely engaged for many years in the Potomac fisheries, whose interest is always manifested in connection with all matters relating to the fisheries, undertook, at the instance of Professor Baird, United States Fish Commissioner, to observe the movements of the young Shad in the Potomac in front of the city of Washington. Their observations show that on November 16, when the thermometer showed the temperature of the water to be 68° F., young Shad were present in the Potomac at Washington in large numbers. From this date the temperature of the water gradually fell, coincident with which the numbers of young Shad decreased until on November 23 the fish had entirely disappeared, the thermometer then showing 58° F. The disappearance of these fish can be referred only to the fact that the water had fallen below 60° F., for as long as that temperature was preserved the fish remained in the portion of the river under observation. The lowering of the temperature of the water seems to present the only variable factor in the conditions which surrounded them, and to this we may reasonably refer their disappearance.

The period of river life.—The deposit of the eggs of the mature Shad in fresh waters seems to be a necessary condition for their development. The idea has prevailed to some

[1] The Chesapeake area includes the Potomac River, the Chesapeake Bay and its tributary streams, and the ocean between Cape Henry and Cape Charles.

extent that the Shad under certain circumstances spawn in salt or brackish waters. Experiments have, however, been made to verify this supposition, but have proved unsuccessful. Whilst impregnation under such conditions has been shown to be possible, and development has proceeded to a certain point, yet before the hatching took place the development of the embryo broke down. The annual migrations of the Shad into our streams are made apparently for the sole purpose of reproduction, excepting in the Saint John's River, Florida, where their first movement into the river seems to be attributable to an influence other than that above mentioned. The time of these migrations into the rivers varies with the geographical position of the river. As a general rule, it is usually later as we proceed farther to the north, though we find some exceptions. It may be stated generally that this migration takes place as soon as the continental waters have become warmer than the salt-water areas into which they discharge. The schools of fish having entered the streams, ascend until they have reached suitable spawning grounds. The deposit and fertilization of the eggs having been accomplished, their development commences, and in a few days, the period varying with the temperature, the young fish, bursting their shells, make their appearance. These remain in the rivers, feeding and growing all summer, and leave late in the fall, at which time they are two or three inches in length. The life history of the Shad from this time is unknown to us. The young fish, having disappeared, do not again come under our observation until they return as mature fish to deposit their spawn.

The motive of their movement into the rivers being for purposes of reproduction, we would expect that with the accomplishment of this desire the mature fish would return to salt water. This is the general impression among fishermen, and may be true as a general fact, but there are instances on record where a full-grown Shad in good condition has been taken in our rivers long after the spawning season is over, and even late in autumn. One of the largest Shad I have ever seen from the Potomac was taken in the vicinity of the White House in the month of November. In the season of 1880, I believe, several full-grown Shad were taken below Holyoke Dam on the Connecticut River in the latter part of the summer. These instances would seem to indicate that under certain conditions the Shad may remain in our rivers during the whole season.

The appearance of the spent fish, or those which have deposited their eggs, enables the fishermen to recognize them at once, and various names have been given to them. From the fact that they are supposed to be moving down the stream when taken, they are called "Down-runners," and from their lean, slim appearance, they are also called "Racers."

The Shad make their first appearance in the Saint John's River about the middle of November, the height of their spawning season in that river being about the 1st of April. In the Savannah River they appear early in January, and in the Neuse River at a period not much later than in the Savannah. In the Albemarle the important Shad seine-fisheries begin early in March, but doubtless the fish are in the Sound some time before that date; not, however, in numbers sufficient to justify the great expenses attendant upon the operation of these large seines. In the Chesapeake Bay they make their appearance in February, although the height of the fishing season in its waters is during April and May, and at a date somewhat later in the more northern tributaries. In the Delaware, Connecticut, Merrimac, and Saint John (Nova Scotia) Rivers, Shad are first seen at periods successively later as we proceed farther north. The date of their first appearance in any of these waters, however, varies from season to season, the limit of such variation being from three to four weeks.

These irregularities in the time of the run into our rivers, which cause so much perplexity and discouragement to the fishermen, are, however, readily explained when we keep in view what

has been already said in regard to the influences of temperature in determining the movements of these fishes.

CAUSES INFLUENCING THE RATE OF MOVEMENT UP RIVERS.—The rate and duration of the movement of Shad in our rivers are influenced by various causes. If, in consequence of warm rains at the river's source, the temperature of the water becomes suitable to the Shad at an earlier date than usual, then their upward movement takes place very rapidly, and, we may say, tumultuously, the great schools of fish crowding in and moving up all at once, so as to produce what is termed a "glut." If, however, the temperature of the river rises by insensible degrees with the advance of the season, then the upward movement begins when the water temperature of the river has passed above that of the sea, and takes place gradually, the rate of movement in such cases being slow and the period prolonged. Again, when the Shad have entered the rivers, the temperature conditions being such as to determine a rapid upward movement, yet should the fish encounter floods and consequent muddy waters, their upward movement is arrested, the schools back down before the flood, and if this condition be prolonged, may be driven entirely out of the river. In short, fluctuations in the river temperature have corresponding influences upon the shad movements; any sudden change, whether to a higher or lower temperature, apparently arresting their upward course for a time, and sometimes even determining a retrograde movement.

Many of the anomalies which perplex fishermen in the course of their work may be explained by the varying movements of the fish, as controlled by the water temperature in the rivers. We find, for example, that while at a particular seine-shore, during one season, a very large catch is made, yet in the following season, although the general run of fish in the river has not diminished, the fishery in the same locality may prove a failure. If we suppose a seine to sweep the flats at the mouth of such a stream as the Occoquan Creek,[1] and if we further suppose that the river waters in the channel are colder than, or as cold as, the waters of the Chesapeake Bay, the Shad in their movement up the river would avoid the main current, and would slowly work their way up along the shores and over the flats, where the temperature of the waters will be found to be, under such circumstances, several degrees warmer than in the channel. Such a season would be profitable to a seine sweeping the flats. Again, if the waters in the main channel of the river were of suitable temperature, then the upward movement of the Shad would take place in the channel and not along the flats. Under such circumstances a "channel seine," *e. g.*, that of the "White House," would make a very large catch, whilst a seine hauled over the flats, as on the Pamunkey shore, would probably find very indifferent fishing.

REPRODUCTION.—The age at which the Shad reaches maturity and becomes capable of reproducing is not definitely determined; it is generally held by fish-culturists, however, that the female Shad attains this condition when three or four years old. The period of maturity for the male, if the relative size of the two sexes be taken as an indication, is much earlier than for the female. Males, or "Buck Shad," weighing less than one and a half pounds (numbers of which always accompany the schools of larger fish), are found to be milters, and at the shad-hatching stations—especially during the earlier part of the season—the spawn-takers are frequently compelled to have recourse to these fish in order to get the milt necessary for the fertilization of the eggs. These fish cannot be more than two years of age. It appears that the first part of the run of fish up the rivers consists almost entirely of males, which precede the females by several days. The records of the fishing shores agree with this statement, their main catch in the earlier part of the season being composed of "bucks," with a very sparing intermixture of "roe Shad," which latter, in their turn,

[1] A tributary of the Potomac River.

increase in proportion as the season advances. The favorite spawning grounds of the Shad, or "Shad Wallows," as they are termed by the fishermen, are on the sandy flats which border the streams, and the sand-bars which are found at intervals higher up the river. When the fish have reached suitable spawning grounds and are ready to cast their eggs, they move up to the flats seemingly in pairs. The time of this movement is usually between sundown and 11 p. m. When in the act of coition they swim close together and near the surface, their back fins projecting above the water. The rapid, vigorous, spasmodic movements which accompany this operation produce a splashing in the water which can be plainly heard from the shore, and which the fishermen characterize as "washing."

The eggs are spun out by the female while in rapid motion. The male, swimming close to her, ejects his milt at the same time, and the contact of egg and milt, and the consequent impregnation of the egg, is coincident with or immediately subsequent to the ejection of the ova from the female. The specific gravity of the egg being slightly greater than that of water, it sinks to the bottom, and, under favorable conditions, develops and hatches out. Large numbers of these eggs are, of course, destroyed by the predaceous fishes that have learned to frequent the spawning grounds of the Shad. A sudden lowering in the temperature of the water may, and frequently does, produce a large destruction of eggs. Floods, too, bring down mud which may smother and destroy vast numbers. But, escaping these casualties, they hatch out in a period of from three to eight days. Unlike the *Salmonidæ*, although with a sac relatively as large, the new-born Shad swim vigorously as soon as they break the shell, and, according to Mr. Seth Green, make their way immediately to the middle of the stream, where they are too small to be an object of prey to the larger fishes, and where the smaller ones dare not come after them.

The number of eggs in the ovary of a Shad, as in all other fish, bears a certain relation to the size and weight of the fish. As the result of experience in the artificial propagation of the Shad we conclude that a ripe roe Shad weighing four or five pounds contains from 20,000 to 40,000 eggs, the average number being about 25,000. A much larger number, however, has been obtained from some individuals. In the season of 1881 we obtained from a single Shad, weighing about six pounds, over 60,000 impregnated eggs; again, in 1880, on the Potomac River, the yield of eggs from a single Shad was over 100,000. These were full-sized, thoroughly impregnated, and were hatched out with a loss of hardly one per cent.

SIZE.—A female Shad of a certain age is always larger than a male of corresponding age. A general average for both sexes along the whole coast would be about four pounds, the extremes—for males—being from one and a half to six pounds, and for females from three and a half to eight pounds, the latter representing a maximum weight for Shad at the present time; although, in the early history of the fisheries, there are records of the capture of fish weighing eleven, twelve, and as much as fourteen pounds. These extreme figures, of course, are for fish which, in consequence of the imperfections of the ordinary kinds of fishery apparatus, the want of skill on the part of the fishermen, or the accidents of fortune have escaped for a long period the fate which befel their less happy companions and have returned to the rivers year after year.

FOOD.—The shad fry, which spend the first six months in our rivers, must of necessity find their food therein. From examinations made of the stomachs of these young fish, they have been found to feed upon certain species of crustacea and insect larvæ, common to the fresh waters of our rivers. During the spring of 1882 some young fry, which were hatched out at Central station, were confined by Dr. John A. Ryder in a glass aquarium, through which the circulation of the water was maintained, and fed with Copepoda, obtained in large quantities from the United States carp ponds. In about seven days after hatching some of the young fry were

observed to eat, and a few days later they were all vigorously engaged in pursuit of food. While the ratio of mortality was large, some of the fish survived for six weeks, the last specimen having attained a length of considerably more than an inch, and a weight many times greater than that at birth.

From these experiments we deem it altogether probable that under natural conditions the Copepoda, which are abundant in the Potomac in places frequented by the young Shad, are their natural food during the early stages of their existence. Although we are able to obtain from the river late in the season young Shad which are two and a half to three and a half inches in length, I am not aware that such examinations have been made upon the contents of their stomachs as to show the character of their food. In order to take observations upon the food of the Shad at the stages indicated above, I procured from the Potomac a number of young Shad, two to three inches in length, which were placed in the basin under the dome of the United States National Museum. These were tempted with various kinds of food; oysters, liver, sturgeon, and beef finely chopped were offered successively to them, but they declined to take the food. In some cases they would seize particles, which having held for an instant they would eject from their mouths with evident expression of disgust. I then tried them with the white of hard-boiled eggs. This, much to my gratification, they devoured readily. As soon as the particles reached the surface of the water, the fish rose vigorously and seized them as they sank through the water, but, strange to say, in no case did I observe them take the food after it had touched the bottom. This would seem to show that their food under natural circumstances is taken swimming, and consists probably of swimming crustaceans, or allied forms of life found in salt water. Later in the season, in consequence of my absence from the city, these fish were neglected and fed irregularly. By way of experiment, I had also placed in this basin a number of young California salmon, and, to my surprise, I discovered that the young Shad were pursuing and eating them. In several cases I noticed the Shad with the salmon in their mouths half swallowed. Finally the salmon disappeared, and the presumption was that they had all been eaten by the young Shad. It is possible, therefore, that Shad in their early lives vary their food with minnows and the young of other species of fish. Indeed, from the stomach of a Shad, taken in one of the pounds at Saybrook, I found an undigested minnow two or three inches in length. In the fresh-water life of the mature Shad, the fish do not seem to take food at all. Repeated observations of the contents of the stomach show no food whatever. Occasionally, however, they can be induced to rise to a fly dexterously cast on the water. This fact is presumptive evidence that the desire for food, although subordinated to the impulse of reproduction (which brings them into the river), is not wholly lost.

180. THE HICKORY SHAD, OR MATTOWACCA—CLUPEA MEDIOCRIS.

By MARSHALL MCDONALD.

NAMES.—This fish, *C. mediocris*, Mitchill, was first brought to notice in 1815 in Mitchill's paper on the fishes of New York, wherein it was described under two names, being called the "Staten Island" Herring, *C. mediocris*, and the "Long Island" Herring, *C. mattowacca*. The latter name was adopted by Storer for the species, but more recent authorities, guided by a rather questionable interpretation of the rules of priority, have substituted the name *C. mediocris*, because it was printed on the page preceding the other. Mitchill stated that the "Long Island" Herring occupied a middle station between the Shad and the "Staten Island" Herring, but it seems strange that so accomplished an ichthyologist should not have at once perceived the identity of the two. The name "*mediocris*" was founded upon small specimens. The names given this species are as

varied as those of the river Herrings. The name "Mattowacca" is of Indian origin, and is perhaps to be preferred. It is said by De Kay to have been derived from the Indian name for Long Island, *Mattowaka or Mattowax*. De Kay also gives the names of "Fall" Herring and "Shad" Herring, and states that in the Connecticut River they are called "*Weesick*," a name which from personal knowledge we can state as having been long in disuse in that locality. The name "Hickory" Shad is applied to this species on all parts of the coast from Cape Cod to Florida. It is used in the Chesapeake and in the Albemarle regions, and on the Ogeechee, Savannah, and Altamaha Rivers, where it is familiarly called "*Hicks*." In the Saint John's River the name "Hickory" Shad is also used, and in the Alabama River it is applied to this or to some closely related species. The derivation of the name "Hickory" Shad cannot easily be traced. It may be that the word "Hickory" is used in a derogatory sense, but a more reasonable explanation is that it refers to the striped markings on the fish, which resemble those upon the coarse cotton fabric known in the South as "Hickory," and frequently used by the fishermen.

also "Hick-ry Jack"

In the Potomac the species is called the "Tailor Shad," or the "Fresh-water Tailor," in contradistinction to the bluefish, which is called the "Salt-water Tailor." The comparison between the bluefish and this species is doubtless due to a fancied resemblance between their jaws, those of the "Tailor Shad" being very long and strong. The "Tailor Shad" may be distinguished from the common Shad and from the river Herrings by the extreme projection and thickness of the lower jaw. This species is in some rivers called a "Forerunner," from the fact that it makes its appearance shortly before the Shad.

It is the opinion of Mr. Perley[1] that the so-called "Quoddy" Herring, taken in Passamaquoddy Bay and vicinity, belongs to this species—a rather questionable decision and one which needs confirmation.

GEOGRAPHICAL DISTRIBUTION.—The "Hickory Shad" is most abundant in the region between the Chesapeake Bay and Altamaha River and intermediate waters, ascending the rivers as high as the Shad. In the Saint John's River it is somewhat abundant, making its appearance the first or second week in November, and shortly before the Shad. North of New York it has not been observed to enter the rivers in any great numbers, and there is no record north of Cape Cod of its having been seen in fresh water. In the fall small schools of them occasionally enter the brackish estuaries and tideways of Cape Cod. Hickory Shad are taken to some extent by the mackerel gill-net fishermen of Maine, together with young Shad and Blue-Back Herring, and are doubtless found off the mouth of the Bay of Fundy; although, as has already been stated, their identity with the "Quoddy" Herring is by no means proven. There is no record of their presence in the Gulf of Saint Lawrence.

ABUNDANCE.—In the Altamaha River, Georgia, the catch of "*Hickory*" *Shad is equal* to that of "Common" or "White" Shad, and in the markets they sell for more than one-half as much. In the Saint John's River they are not exceedingly abundant, and two "Hickory" Shad are equal in value to one "White" Shad. In the Ogeechee and Savannah Rivers the proportion of the catch of the "Hickory" to that of "White" Shad is about one to four. All taken here are used for local consumption, and are sold at prices equal to about one-half of the White Shad. In the Albemarle they are less abundant than farther south and are of less value. Here they are sold with the herring for local consumption, two of them counting for one herring, or are used for manure. In the Chesapeake region they are not highly esteemed, although great quantities are sold by hawkers, especially in the cities, where people are not well informed, under the name of "Shad." At the

[1] Fisheries of New Brunswick, 1852, p. 209.

beginning of the season hundreds of men may be seen going about the city of Washington with strings of these fish, which they cry for Shad, and which with great insolence they press upon such would-be purchasers as are inclined to question their genuineness. In the pound-nets of the Chesapeake in the beginning of the season they are caught in immense numbers, and are shipped to the markets with the true Shad until their price falls below three cents apiece, after which they are sold with the Herring, one counting as two Herrings. The "Hickory" Shad are occasionally seen in the fall and winter in the New York market. Mitchill, writing in 1814, remarks: "Some call this fish the 'Shad' Herring and some the 'Fall' Shad. He is reckoned to be almost equal to the Shad as an article of food." Storer states that in Massachusetts it is a lean fish, and not used for food.

Concerning the "Quoddy" Herring, Perley writes that in flavor and excellence it ranks only second to the best Shad of the Petitcodiak.

SIZE.—Mitchill states that the length of this fish is frequently twenty to twenty-four inches, its depth is often four and a half to six inches, and that it sometimes attains a weight of four or five pounds. At the present time, however, the size of the fish is much less than that described by Mitchill. The largest full-roed specimen observed by Colonel McDonald cannot have exceeded three to three and a half pounds in weight.

REPRODUCTION.—No observations have been made on the breeding habits of this fish, but it is almost certain that it spawns in spring, like the other members of the family, but whether in salt or fresh water has not been ascertained. It seems more than probable, however, that it spawns in fresh water under the same conditions as the Shad, at a little earlier period.

T.—FAMILIES RELATED TO THE CLUPEIDÆ.

181. THE MUD-SHAD—DOROSOMA CEPEDIANUM.

The family *Dorosomatidæ* is represented on our Atlantic coast by a single species, the "Mud-Shad," *Dorosoma cepedianum*, which is abundant in brackish waters along the coast from Delaware Bay southward to Mexico. In the Chesapeake region it is known as the "Mud-Shad," "Winter Shad," or "Stink Shad"; in North Carolina as the "Hairy-back" or the "Thread Herring"; in the Saint John's River as the "Gizzard Shad," "Stink Shad," or "White-eyed Shad."

The names "Gizzard Shad" or "Hickory Shad" refer to the peculiar muscular stomach, which is of about the size of a hickory-nut and is shaped like the gizzard of a fowl. The fish is found in brackish waters, or in the sea, for the whole length of our coast. It enters all streams after becoming land-locked in ponds, and throughout the whole Mississippi Valley it is permanently resident in large numbers in the larger streams and reservoirs. Since the construction of the canals it has appeared in force in Lake Erie and Lake Michigan.

This fish is extremely abundant in many localities, particularly in the Saint John's River, Florida, where it becomes an annoyance to the fishermen by getting into their nets, several hundred bushels being sometimes taken in a shad net. They are also sometimes annoying to fishermen using gill-nets for catching mullet. In the Potomac they are abundant and attain a maximum size and weight. Their flesh is coarse and not delicate in flavor, but they are by no means unpalatable, and on the tributaries of the Chesapeake they are extensively eaten by the negroes. In the Saint John's River they are made into guano. A factory for this purpose was in existence in 1874 at Black Point, above Palatka. They breed in summer, and are supposed to feed, like the Menhaden, to a great extent upon the bottom mud, from which, after swallowing, they separate the organic contents.

In the Great Lake regions the Gizzard Shad is sometimes split and salted as "Lake Shad," but it probably meets with little sale, owing to the inferior quality of the flesh and the presence of the vast number of small bones that make up the skeleton. It is usually thrown away by the fishermen, and when brought to market it is only bought by the poor or the ignorant. It is not infrequently seen in the markets of Washington in spring. In the West it is sometimes seined by farmers in winter in still places in the rivers and peddled about the towns.

182. THE TARPUM—MEGALOPS THRISSOIDES.

In our waters the most important member of this family is the Tarpum, *Megalops thrissoides*, an immense herring-like fish, which occurs in the Western Atlantic and in the Gulf of Mexico, ranging north to Cape Cod and south at least to Northern Brazil. It is somewhat abundant in the West Indies, and stragglers have been taken as far to the eastward as the Bermudas. This species attains the length of five or six feet, and is covered with enormous circular scales of one inch to two inches and a half in diameter, the exposed portions of which are covered with a silvery epidermis. The fish, when alive, presents a very brilliant metallic appearance, and the scales are much prized by curiosity hunters and for fancy work in the Florida curiosity shops. They are a staple article of trade, selling for from ten to twenty-five cents each, the price paid to the fishermen being about fifty cents per dozen.

The sailors' name for this fish, by which same name it is also known at Key West, Bermuda, Brunswick, Georgia, and elsewhere, is "Tarpum" or "Tarpon." In Georgia and Florida it is commonly called the "Jew-fish," a name also applied by the fishermen of South Florida to a species of percoid which has already been discussed. It is the "Silver-fish" of Pensacola, the "Grande-Écaille" (Large-scale fish), or "Grandykye," as it is pronounced and sometimes spelled, and the "Savanilla" of Texas.

The species can hardly be said to be common on our Atlantic coasts, though from fifty to one hundred specimens are doubtless taken every year between Florida and Cape Cod. In 1874 and 1875 none were caught in the Saint John's River, though several had been brought in during the previous winter. In the Indian River region these fish are sometimes harpooned.

Mr. Stearns contributes the following notes upon the fish, as observed by him:

"The Silver-fish, or Grande Écaille, is common everywhere on the Gulf coast. It is an immense and active fish, preying eagerly upon schools of young fry, or any small fish that it is able to receive into its mouth, and in pursuit of which it ascends fresh-water rivers quite a long distance. During September, 1879, I saw large numbers of Silver-fish eight or ten miles up the Apalachicola River, and am told that that was not an unusual occurrence. They go up the Homosassa River in Florida, and several of the Texas rivers, so I have subsequently learned. The Tarpum will take a baited hook, but it is difficult to handle and seldom landed. The Pensacola seine fishermen dread it while dragging their seines, for they have known of persons having been killed or severely injured by its leaping against them from the seine in which it was inclosed. Even when it does not jump over the cork-line of a seine, it is quite likely to break through the netting before landed. I have secured several specimens, the smallest of which weighed thirty pounds and the largest about seventy-five pounds."

The Tarpum is sometimes eaten, and is said to be very palatable.[1]

183. THE BIG-EYED HERRING.

The "Big-eyed Herring" or "Ten-pounder," *Elops saurus*, was described by Linnæus from a Carolina specimen sent to him by Garden. It occurs all along the coast from Martha's Vineyard southward, but only in the summer in the northern part of its range. It is cosmopolitan in its distribution, occurring throughout the West Indies, on the coast of South America, on both coasts of Mexico, at the Cape of Good Hope, in East Africa, Arabia, and China. At Fort Macon it is known as the "Horse Mackerel." It is rarely or never eaten in the United States, its flesh being said to be dry and bony.

184. THE ANCHOVIES—ENGRAULIDÆ.

A species of Anchovy, *Stolephorus Browni*, is extremely common about Fort Macon, where it is known as the "Sardine" and occurs in large schools. Specimens of this and of an allied species (*S. Mitchilli*) are occasionally taken in the vicinity of Wood's Holl, Massachusetts, and in greater abundance in New Jersey.

The presence of a true Anchovy in America was first announced by Professor Baird in 1854. A species was noticed by Mitchill, but its relations to the Anchovy of Europe were not recognized. In his Report on the Fish of the New Jersey Coast, Professor Baird remarked of *S. Browni*: "The Anchovy made its appearance early in August in the shallow waters along the beach, though of very small size; it subsequently became more abundant, and towards the end of the month, while hauling a large net in the surf, many were taken, measuring over six inches in length; as the

[1] See statement of W. H. Burrall, Forest and Stream, ii, 1874, p. 324.

meshes of the net were large, a great portion escaped, but with a seine properly constructed enough could be secured to supply the American market. I procured several specimens of this fish in 1847 at the residence of Mr. Audubon, on the Hudson River above New York."

There is little reason to doubt that this species of Anchovy might be prepared in salt or in paste, like that of Europe, and that the results would be equally satisfactory; as an actual fact, however, most of the Anchovies put up in Europe do not belong to this genus at all, but are simply pilchards or sprats preserved in a peculiar manner, the name "Anchovy" having come to be descriptive of a peculiar method of preparation rather than of the fish which is prepared. Our Anchovy has recently been sold in considerable numbers in New York under the name "Whitebait," although the fishermen distinguish it from the true "Whitebait," the young of the herring, calling it "Spearing."[1]

CALIFORNIA ANCHOVY—STOLEPHORUS RINGENS.

The Anchovy of the Pacific coast is reported by Jordan to be of little economic value. The commonest form is what he calls the California Anchovy, *Stolephorus ringens*, and which is thus described by him:

"This species is everywhere known as the Anchovy. It reaches a length of about six inches. It ranges from British Columbia to Chili, and is probably found on the coast of Asia also. It is found in sheltered bays, and is everywhere extremely common, but rather more abundant south of San Francisco than northward. It serves as food for the larger species to a greater extent than any other single species. The salmon, bonito, mackerel of all sorts, barracuda, sea-bass, the larger flounders, and, in fact, a majority of the larger fishes make a large percentage of their food of Anchovy. At San Francisco it is occasionally brought into the market. Some attempts have been made to pickle them with spices for the trade, but this amounts to little as yet. A great many are salted by the Chinese, who use them as bait for the flounders and rock-fish. Two other species of Anchovies, *Stolephorus compressus* (Grd.) and *Stolephorus delicatissimus* (Girard), abound south of Point Concepcion. They have no economic value."

185.—THE LADY-FISH FAMILY—ALBULIDÆ.

The Lady-fish, *Albula vulpes*, occurs in the West Indies, in the Gulf of Mexico, on the Atlantic and Pacific coasts of North and South America, and stragglers have been found in the Western Atlantic as far north as Cape Cod. It is also found about the Bermudas and Cape Verde Islands, in the Indian Ocean, the Red Sea, and on the coast of Japan. With us it is usually called the "Lady-fish"; in the Bermudas the "Bone-fish," or "Grubber." At the Bermudas large schools are taken, and there considered most excellent food-fish. From personal observation I can testify that their reputation is by no means a false one. The "Lady-fish" doubtless occurs about Key West, although the National Museum has as yet received no specimen from that locality. The species is found in some numbers in San Diego Bay, on the coast of California, where it is taken with the mullet. On account of its beautiful color it sells readily, but is not especially esteemed as a table fish.

186.—THE MOON-EYE FAMILY—HYODONTIDÆ.

Three species of this family are known by the names of "Moon-eye," *Hyodon tergisus* Le Sueur, "Toothed Herring," *Hyodon alosoides* (Raf.) J. & G., and "Silver Bass," *Hyodon selenops* Jor. & Bean. The first-named species is abundant throughout the Lake region and the larger tributaries

[1] J. C. Brevoort states that while trolling in August, 1873, near New York light-ship, every bluefish captured was gorged with the American Anchovy. The Anchovy is preserved by salting or by grinding into fine paste with salt. They may be caught with fine purse-nets.

of the Mississippi; the second is found in the Ohio Valley and northward to the Upper Missouri and Saskatchewan; the third is confined to the rivers of the Southern States. None of the species occur east of the Alleghanies. They are little valued as food.

The Moon-eye—Hyodon tergisus.

The Moon-eye is a handsome and gamy fish, taking the hook readily, and feeding upon minnows, crustaceans, and insects. It reaches a weight of one to two pounds. In Lake Pepin, according to Dr. D. C. Estes, "in some seasons they seem to be quite plenty, and at others but very few are seen. On the whole, I have always regarded it as a rare fish. They are vigorous biters, and are as gamy as the striped bass (*Roccus saxatilis*). They take freely the minnow or fly, and are one of the smartest of fishes. They will come up, taste of a fly, let go and be gone before the angler has time to strike. Therefore, to be a 'Moon-eye' fly-fisher, one must be very sharp and not read a book while casting, as I once knew a man to do. As to his being a food-fish there is not a single doubt. I ate one this very morning for my breakfast, and it was excellent, the bones being far less in number and of larger size than in the herring."

U.—CARP, SUCKERS, CATFISH, AND EELS.

187. THE SUCKER FAMILY—CATOSTOMIDÆ.

By DAVID S. JORDAN.

The members of this family, known as "Suckers," "Mullets," "Red Horse," "Buffalo fish," etc., are extremely abundant in all fresh waters of the United States, no stream or pond containing fish at all being without them. As all of them reach a length of more than a foot, and are found in the markets, all must be considered as food-fishes. In all of them the flesh is coarse and flavorless, and the number of small bones is provokingly great. They are therefore always the cheapest of fish-food, while from their great numbers they form a large percentage of the food supply of the country. Their value is no more than the cost of catching, and often less. The Suckers feed on mollusks, insects, entomostracans, fish-spawn, and some of them chiefly on mud. They rarely catch other fishes. Like the *Cyprinidæ*, they form a large part of the food of the larger carnivorous fishes. The Suckers spawn in spring, many of the species ascending small streams for that purpose. At this season great numbers of them are speared or snared on shallow rapids. The distribution of the different species can be ascertained by reference to the check-list, and only a few of the most important need be mentioned here.

THE RABBIT-MOUTH SUCKER—QUASSILABIA LACERA.

The "Rabbit-mouth," "Hare-lip," "Split-mouth," or "May Sucker" is found in abundance in many rivers of Tennessee and in some streams in Ohio. It reaches a length of about eighteen inches, being one of the smaller species, but its qualities as a food-fish are said to be better than usual in this family.

THE RED HORSE—MOXOSTOMA MACROLEPIDOTUM.

The common "Red Horse" or "Mullet" abounds in most streams westward and southward of New York. It reaches a length of two feet, and is a market fish of importance. Its coloration is attractive, but its flesh is tasteless and coarse. Numerous other species closely related to the Red Horse, belonging to the genera of *Moxostoma*, *Minytrema*, and *Placopharynx*, are found in the waters of the West and South, all going by the general names of Red Horse, White Sucker, and Mullet. All are alike poor as food-fishes.

THE CHUB SUCKER—ERIMYZON SUCETTA.

The "Chub Sucker," "Sweet Sucker," or "Creek-fish" is one of the most abundant and widely diffused of the Suckers, being found from Maine to Texas. It is one of the smallest species, reaching a length of little more than a foot. It is not essentially different from the rest as food. A closely related species (*E. Goodei*) abounds in Florida.

THE COMMON SUCKER—CATOSTOMUS COMMERSONI.

The common "Brook Sucker" is the most familiar and generally abundant of the group. It inhabits all bodies of water, large and small, from New England to Colorado. In the Great Lakes

* In N. C. a species of Moxostoma (M. carpio) is known as "Carp Mullet," being listed as a food-fish in spring & fall. See Plate 222 B. (- W.A. Brady. Editor)

it reaches a length of two feet or more. In small brooks it is mature at eight or ten inches. It is a soft, poor fish. It varies much in size, color, and form in the different streams. It bites at a small hook baited with a worm, and is one of the numerous tribe of boy's fish which may be found on every urchin's string.

All the lakes and rivers of the Rocky Mountain region and the Pacific slope are inhabited by one or more species of this genus, or of the allied genera *Chasmistes* and *Pantosteus*. In Utah Lake, said to be the "greatest Sucker-pond in the world," are found *Catostomus fecundus* and *ardens*, *Chasmistes liorus* and *Pantosteus platyrhynchus*, all in abundance. In Lake Tahoe, *Catostomus tahoënsis;* in the Sacramento *C. occidentalis;* in the Columbia *C. macrochilus;* in Klamath Lake, *Chasmistes luxatus* and *Ch. brevirostris*, abound, while in the Great Lakes and all waters thence to Alaska and the Arctic Ocean *C. longirostris* is an important food-fish. The Stone-roller or Hammer-head Sucker, *Catostomus nigricans*, abounds in most waters from the Great Lakes southward. The Stone-roller is extremely abundant in every running stream in the North and West, where its singular, almost comical form is familiar to every school-boy. It delights in rapids and shoals, preferring cold and clear water. Its powerful pectorals render it a swifter swimmer than any other of its family. Its habit is to rest motionless on the bottom, where its mottled colors render it difficult to distinguish from the stones among which it lies. When disturbed it darts away very quickly, after the manner of the etheostomoids. They often go in small schools. I have never found this fish in really muddy water, and when placed in the aquarium it is the first fish to die as the water becomes foul. Although called the "Mud Sucker" in the books, it is most characteristically a fish of the running streams. This species reaches a length of about two feet, and is often caught in its spawning season by means of a spear or snare. It is, like *C. Commersoni*, a "boy's fish," and not worth the eating.

The Black Horse—Cycleptus elongatus (Le S.) Ag.

The "Black Horse," "Gourd-seed Sucker," "Missouri Sucker," or "Suckerel" is found chiefly in the river channels of the Ohio and Mississippi. It reaches a considerable size, weighing five to twelve pounds, and is said to be a much finer fish in flesh than any other of its family. The writer has had no opportunity of testing this.

The Carp Sucker—Carpiodes cyprinus.

The different species (*Ictiobus cyprinus, carpio*, etc.) known as "Carp," "Carp Suckers," "Spear-fish," "Sail-fish," "Quill-back," etc., abound in all the larger bodies of water south and west of New York as far as the Rio Grande. The species are probably but two in number, very similar. They reach a weight of four or five pounds, and form an abundant but not excellent food.

The Buffalo-fishes.

The three species known as "Buffalo-fishes" (*Ictiobus bubalus, urus*, and *cyprinella*) are found mainly in the river channels of the Mississippi and its tributaries. They are the largest of the Suckers, reaching a weight of fifteen pounds or more. In the Mississippi and Ohio Valleys they form a large percentage of the food-fish consumed. They usually bring a better price than the smaller Suckers, excepting the Black Horse, but at the best they are coarse, poor fishes, the flesh being full of small bones and scarcely worth the trouble of picking. The Buffalo-fishes are found by Professor Forbes to feed on small crustaceans more than do the other Suckers, and less on mollusks.

188. THE CARP FAMILY—CYPRINIDÆ.

By DAVID S. JORDAN.

The species of this family known as "Minnows," "Chubs," "Shiners," and "Dace" literally swarm in all of the fresh waters of the United States, as in those of Europe and Africa. Most of them reach a length of less than six inches. Such have of course no value as food. They are, however, important as furnishing the greater part of the food of all our carnivorous fresh-water fishes—the bass, perch, trout, pike, etc. A few of our species reach a considerable size, especially in the Sierra Nevada region. Some of these become food-fish of importance. The flesh in all is, however, deficient in flavor and full of small bones. Not one of our native species has any high money value, and only the Carp (*Cyprinus carpio*), of all the family, can be compared as a food-fish with the percoids and salmonoids.

Most of the *Cyprinidæ* are carnivorous, the smaller species feeding upon insects, fish-spawn, etc. Many large individuals are quite voracious, some of them being very destructive to young trout. All of them spawn in spring, some of them running up small brooks for that purpose.

Some of the more important of our *Cyprinidæ* are the following:

THE GOLDEN SHINER—NOTEMIGONUS CHRYSOLEUCUS.

This fish, the American representative of the European Bream, abounds in most rivers east of the Great Plains. It is a sluggish fish, frequenting ponds, bayous, and cut-offs, preferring those in which the bottom is covered with aquatic plants. It reaches a length of nearly a foot, and is sometimes brought to market.

THE CHUB OF UTAH LAKE—SQUALIUS RHOMALEUS.

This species is excessively abundant in Utah Lake, and as it ascends the streams to spawn almost simultaneously with the trout (*Salmo purpuratus*), it is extremely destructive to the young of the latter. It is taken in considerable numbers in seines, and is sold in the markets of Salt Lake City and other towns. It reaches a length of nearly a foot.

Numerous other species, belonging to the same genus and similar in size and habits, abound in the region between the Rocky Mountains and the Sierra Nevada, and are used as food by the Indians and by the white settlers. Among these are *S. niger*, *S. purpureus*, *S. obesus*, *S. pandora*, etc. Species very similar abound in Europe and Asia.

SQUALIUS GIBBOSUS.

The "Chub" of the San Francisco markets abounds in the Sacramento River, and is taken in great numbers. It reaches a length of about a foot, and is eaten chiefly by the Chinese.

GILA ELEGANS.

The various species of *Gila* abound in the basin of the Rio Colorado and Rio Gila, and are used as food in New Mexico and Arizona. They reach a length of about eighteen inches. *Gila elegans*, *robusta*, and *Grahami* are the principal species.

THE SACRAMENTO "PIKE"—PTYCHOCHILUS OREGONENSIS.

This species abounds in the Columbia and Sacramento Rivers and their tributaries, where it is usually known as the "Pike." It reaches a length of three or four feet at least, a size much greater than that of any other of our representatives of this family. A great many are brought into the markets of San Francisco in the winter. Its flesh is of course not much esteemed. A

second species (*Ptychochilus Harfordi*) accompanies *P. oregonensis* in the Sacramento, and is brought with it to the markets. A third species (*Ptychochilus lucius*) occurs in the lower course of the Rio Colorado, and is said to reach a still larger size—a length of five or six feet.

Mylopharodon conocephalus.

This species occurs with *Ptychochilus oregonensis* in the Sacramento, and is brought with it into the markets. It reaches a size scarcely less than that of *P. oregonensis*, but is less plentiful.

Mylochilus caurinus.

This species abounds from California to Puget Sound in all the streams of Oregon, Washington, and Idaho, and often enters the sea. It reaches a length of little more than a foot, and is little used for food where trout and other better fishes abound. Its great numbers, however, give it a special claim to notice.

The Split-tail—Pogonichthys macrolepidotus.

The "Split-tail" is very common in the Sacramento, and is brought in considerable numbers to the San Francisco market. It reaches a length of about eighteen inches.

The Fall-fish—Semotilus bullaris.

The "Fall-fish," "Chub," "Roach," or "Dace" is abundant in the streams of the Eastern and Middle States east of the Alleghanies. It reaches a length of eighteen inches, being the largest of the *Cyprinidæ* east of the Rocky Mountains. It has no special importance as a food-fish, although often taken with hook and line. According to Thoreau, the Chub is a soft fish and tastes like brown paper salted.

The Horned Dace—Semotilus corporalis.

This species abounds in all small streams and ponds from Western Massachusetts to Nebraska and southward. It reaches a length of about a foot, and is *par excellence* a small-boy's fish. Large specimens are often found in streams which the boy can step across, and a small hook baited with an angle-worm will draw the fish from its lurking place. The "horns" in this and other Minnows and Chubs are dermal excrescences developed on the males in the breeding season.

The Horny-head—Ceratichthys biguttatus.

The "Horny-head," "River Chub," or "Jerker" is one of the most widely-diffused of fresh-water fishes, occurring from New York to Utah and Alabama. It reaches a length of ten or twelve inches. It inhabits larger streams than the Horned Dace, which delights in little brooks. It takes the hook readily, and throughout the Southwest forms a source of satisfaction to the juvenile angler. The flesh of this and other small *Cyprinidæ* is very palatable when fried crisp soon after being taken from the water.

Platygobio gracilis.

Toward the Northwest this Chub takes the place of the preceding, and reaches a somewhat larger size.

The Shiner—Minnilus cornutus.

The "Shiner," "Red-fin," or "Red Dace" abounds in all streams from New England to Kansas and Alabama, being in most waters more numerous than any other species. In clear, cool lakes it is often found in great schools. At the mouths of small rivers in Lake Michigan

hundreds of them can be taken in a short time on a small hook baited with worms or flies. This species reaches a length of about ten inches. It assists to swell the urchin's string, but has no tangible importance as a food-fish. Its flesh spoils very quickly after the fish is taken from the water, hence the name "Rot-gut Minnow," applied to it in Alabama. A large part of the food of the black bass, trout, and other predatory fish is contributed by the Shiner and by its numerous congeners.

THE CUT-LIPS—EXOGLOSSUM MAXILLINGUA.

The "Cut-lips," "Day Chub," or "Nigger Chub," has but a narrow distribution, being found in abundance only in the basin of the Susquehanna. It reaches a length of six or eight inches, and has no economic importance.

LAVINIA EXILICAUDA.

This species is found in some abundance in most streams of California, and comes occasionally into the markets. It reaches a length of about fifteen inches.

ORTHODON MICROLEPIDOTUS.

This species occurs in most streams of California in considerable abundance. A good many are sent to the market of San Francisco, where they are eaten by the Chinese. It reaches a length of about eighteen inches.

HARD-MOUTH—ACROCHILUS ALUTACEUS.

The Hard-mouth Chub is found in the rivers of Washington and Oregon. It reaches a length of about a foot but is only rarely eaten.

189. THE CARP—CYPRINUS CARPIO.

By RUDOLPH HESSEL.[1]

THE RACES OF CARP—THEIR HISTORY AND HABITS.—The Carp, *Cyprinus carpio*, of the family *Cyprinidæ*, has a toothless mouth, thick lips, and four barbels on the upper jaw. In place of the usual teeth of the mouth there are a number of stout teeth on the pharyngeal bones, which are arranged in three rows. It has one single dorsal, which is longer than the anal. Both these fins have at their origin, on the anterior edge, a strong ray, which is serrated in a downward direction. The caudal is of semicircular shape, and the natatory bladder is divided into two sections, with connecting air-passage. The scales have an entire edge, and the body is compressed on the sides. The general color of the back and sides is a dark olive-brown, the abdomen often of a whitish-yellow or orange tint. The coloring depends, as with all fishes, partly upon the age and season, partly upon the water, the soil, and also upon the food of the fish.

Be it remarked that the Carp, which has occasionally been compared to the buffalo-fish, has no resemblance to it, with the exception of the similarity of their coat of scales; neither does the flesh of the buffalo-fish ever come up to the excellence of that of the Carp.

The Carp was, in all probability, originally introduced into Europe from Central Asia many centuries ago, and is now common in most of the large rivers. In some parts of Europe, principally in Bohemia, Austria, Southern, Central, and Northern Germany, it has become domesticated.

The Carp is alleged to have been imported into England in the year 1504. In Austria, which possesses the most extensive carp fisheries in Europe, the culture of the Carp can be traced as far back as the year 1227. The Emperor Charles IV of Germany, by granting sundry privileges,

[1] Extract from Report of United States Fish Commission, part iv, 1875–'76, pp. 865–876.

favored the establishment of ponds in his dominions, and the monks were especially assiduous in the culture of fish in ponds. As early as the first half of the fourteenth century, Bohemia had its first large carp pond, and the culture of this fish progressed in that country, as also in Poland, and that district which now comprises German Austria; also in Upper Lusatia, Saxony, Silesia and Bavaria. A celebrated establishment for carp-culture, with large, extensive ponds, was located, as early as the fourteenth century, near the town of Wittingau, in Bohemia, Austria. The first beginning of it may be traced back to the year 1367. At that time the lords of Rosenberg called into existence and maintained for centuries these establishments on a scale so extensive that to this day they are the admiration of the visitor, the main parts having survived, while the race of the Rosenbergs has long been extinct.

The manor of Wittingau suffered greatly from the calamities of the Thirty Years' War, and with it, in consequence, its fish-culture. The latter only recovered the effects of it after passing, together with the large estate of a rich monastery of the same name, in the year 1670, into possession of the princes of Schwarzenberg, their present owners. The extent which carp-culture has reached on these princely domains will be seen from the circumstance that their artificial ponds comprise an area of no less than twenty thousand acres. The proceeds amount to about five hundred thousand pounds of Carp per annum. The ponds of the princes of Schwarzenberg are probably the most extensive of the kind on the globe. They are usually situated in some undulating low-land country, where small valleys have been closed in by gigantic dams for the purpose of forming reservoirs. Similar establishments, though not equally extensive, are found in the provinces of Silesia and Brandenburg; as, for instance, near Breslau and Cottbus, in Peitz and Pleitz, which I visited last year. In Hesse-Cassel, Hanover, Oldenburg, Mecklenburg, and Holstein there are also many hundreds of ponds, none of them covering more than a few acres, but almost every large farm possessing at least one of them.

It will be easily understood that after such an exclusive culture in ponds, continued through centuries, as also an existence in open water, where the *Cyprinidæ* were left more to themselves, a number of varieties or rather genuine species *Cyprinus carpio*, showing striking differences from the races, were developed: these races, though derived directly from the original type, just as with our domestic animals. They are divided into three chief groups:

1. *Cyprinus carpio communis*, the "Scale Carp"; with regular, concentrically arranged scales, being, in fact, the original species improved.

2. *Cyprinus carpio specularis*, the "Mirror Carp"; thus named on account of the extraordinarily large scales which run along the sides of the body in three or four rows, the rest of the body being bare.

3. *Cyprinus carpio coriaceus, sive nudus*, the "Leather Carp"; which has on the back either only a few scales or none at all, and possesses a thick, soft skin, which feels velvety to the touch.

The two last named are distinguished from the original form by a somewhat shorter and stouter but more fleshy body. It is rather difficult to decide which of these three species is the most suitable for culture. There are some districts where only Scale Carp are bred and Mirror Carp are not valued, as there is no demand for any but the former in the market, as, for instance, in Bohemia, in the above-mentioned domain of Wittingau. Again, in other districts, as in parts of Bavaria and Saxony, etc., for the same reason, Mirror Carp or Leather Carp only are bred. There is, in fact, no sufficient reason for making any distinction among these three varieties, for if they are genuine types of their respective species, they are indeed excellent and desirable fish.

The assertion which has been made at times that the Scale Carp is better adapted for transportation than either the Mirror or Leather Carp by reason of its coat of scales, which would pro-

tect it more efficiently from the accidents incidental to transfer, as also against inimical or hurtful attacks in the ponds (the Mirror Carp having very few and the Leather Carp no scales), is not correct. In transportation scales are not only inefficient for protection, but they frequently cause the death of the fish, especially in transporting the so-called breeding fish; for if a scale be torn off in part only ulceration will ensue, and the fish, of course, will die. Again, should any scale be lost, the bare spot will very soon begin to fester, or develop a confervaceous growth, and the consequences will be the same. On the contrary, the Leather Carp, which oddly enough, like the frog, is destitute of covering, will bear a great deal more ill-usage and injury, whether young or old, than the Scale Carp. The smooth, slippery skin of the Leather Carp suffers much less from friction during transportation than the Scale Carp, and any slight wound will heal up much more easily, as the epithelium will cover it immediately and the formation of a new skin can progress under its protection. I have often had the opportunity of seeing such scars upon the skin of the Mirror Carp, and even more so on that of the Leather Carp. They are the effects of injury from the sharp edges of the heron's bill, the bite of a pike, or some other hurt, and I never saw anything of the kind on a Scale Carp, for if one of these be wounded it almost invariably dies.

The Carp will sometimes cross with some related species of the *Cyprinidæ*, for instance, *Carassius vulgaris;* and, in consequence, hybrids have been engendered which sometimes resemble the genuine Carp so much that it is often difficult for the student as well as for the professed culturist and experienced fisherman to immediately recognize them. Such fishes are valueless as food, on account of their bad and very bony flesh. One of the hybrids mentioned is the *Carpio Kollarii—Cyprinus striatus*, which was formerly regarded as a separate species. It is a cross between the Carp and *Carassius vulgaris* (crucian Carp), a very poor and bony fish, which, in Germany, is sometimes called "Poor man's Carp." Some varieties exist of this common fish. The latter has even been dignified by a specific name of its own, *Carassius gibelio.*

The spawning seasons of the crucian and the true Carp coincide, and, where kept together, hybrid races may readily be formed; that period including the time from the month of May until August.

In order to determine this question, I myself managed to bring about such crosses by placing (1) female common Carp with male crucian Carp, and (2) female crucian Carp with male common Carp, in small tanks, constructed with this end in view; (3) I also put together female *Carpio Kollarii* with male common Carp; this for the sole purpose of testing the capability of propagation of the *C. Kollarii*, which had been doubted. In the two former cases I obtained forms analogous to the *Carpio Kollarii* sometimes approaching in appearance the true Carp, at others the crucian Carp. In the third case, however, having placed ripe *Carpio Kollarii* together with *Cyprinus carpio*, I obtained a product with difficulty to be distinguished from the genuine Carp. I took the trouble to feed them for three years, in order to try their fitness for the table, but their flesh was exceedingly poor and very bony, and could not be compared by any means to that of the common Carp.

Considering, then, the whole extensive tract of country devoted to fish-culture in Central Europe, where crucian Carp are to be found from Italy to Sweden and Norway, from France to the boundary of Eastern Siberia, considering the many who cultivate on a small scale and the owners of badly stocked ponds, with their different doubtful productions, how often do we find in the markets or ponds very nice crosses which have been propagated through from three to ten generations and which are sold for Carp! There are many small sheets of water in Germany, France, Austria, Italy, Holland, and Belgium, and probably also in England, the proprietors of which imagine, in good faith, that they have stocked their ponds with good, genuine Carp, which in

reality, through careless selection or ignorance, are hybrids which may even have been cultivated for two or three generations. In some ponds in Switzerland, near the lake of Constance, some crosses of *Abramis brama* were found as late as twenty years ago.

HABITS.—The Carp is partial to stagnant waters, or such as have a not too swift current, with a loamy, muddy bottom and deep places covered with vegetation. It inhabits now most of the larger and smaller rivers of Europe, particularly the Elbe, Weser, Rhine, Danube, Po, Rhone, Garonne, Loire, then the Bavarian and Swiss lakes, the lake of Constance, etc.; even salt water seems to agree with it very well. I have taken it in the Black Sea, where its weight often amounts to from fifteen to twenty pounds. It is also found in the Caspian Sea in great numbers, and is known there by the name of *Sassan*.

It is an advantage that the Carp is able to live in water where other fishes could not possibly exist; for instance, in the pools of bog meadows or sloughs. However, it is not by any means to be inferred from this that the best locality for carp ponds of a superior kind could be in such situations. The presence of too much humic acid is unfavorable to the well-being of the Carp, as we shall see presently in the chapter upon the establishing of fish-ponds.[1]

The Carp lives upon vegetable food as well as upon worms and larvæ of aquatic insects, which it turns up from the mud with the head. It is very easily satisfied, and will not refuse the offal of the kitchen, slaughter-houses, and breweries, or even the excrement of cattle and pigs. I propose to enter further upon the subject of feeding it when I speak of its culture in ponds.

In the moderate zone, that is to say in Central Europe, the Carp will, at the beginning of the cold season, seek deeper water to pass that period in a kind of sleep. This will sometimes occur as early as the beginning of November, if the winter should set in early; and it is to be remarked that they will retire at an earlier period in ponds than in rivers. They do so always in groups of from fifty to one hundred and more. They make a cavity in the muddy ground, called a "kettle"; in this they pass the time until spring, huddled together in concentric circles with their heads together, the posterior part of the body raised and held immovably, scarcely lifting the gills for the process of breathing, and without taking a particle of food. They do not take any food from the beginning of October, and continue to abstain from it, in some countries, until the end of March, and in colder districts even somewhat later. It will not answer, however, to depend on this habit when transporting them for propagation in the spring or winter time, more especially young Carp one or two years old. The fish will arrive in a worn and hungry condition, and must be kept in a tank constructed on purpose for observation, where it has no chance to bury itself in the mud; here it will sometimes take a little food. At such times I generally make use of boiled barley, or rye flour converted into a kind of tough paste by the addition of hot water, and with this I mix a little loam and dry bread; but I continue the feeding only until I can judge from the looks of the fish that they have recovered. This method I followed with the Carp which I imported from Europe for the purpose of breeding in the winter of 1876–'77. It is a most striking fact that the Carp, though it does not take any food during this winter sleep in its natural retreat, does not diminish in weight, while, in the so-called "winter chambers," it does so to a remarkable degree. These "winter chambers" are large tanks, one thousand to five thousand square feet in size or less; they are sometimes walled in with masonry, sometimes they are constructed of wood. Fishes intended for sale are kept in them for a few weeks or months during the winter.

The Carp does not grow in the winter. Warmth alone seems to exercise a favorable influence upon it and to promote growth. It only grows in the months of May, June, July, and August, and does not appear to continue doing so in September. This slight increase in weight which

[1] Report United States Fish Commissioner, pt. iv, p. 876 *et seq.*

takes place during the latter month seems to grow out of an accumulation of fat which is being deposited around the entrails. In ponds which contain plenty of food and healthy water, in an ordinary year, the growth and increase of weight in the year will be represented in figures as follows:

	Per cent. of original weight.	Per cent. of growth.
May	10–15	13
June	33	31
July	36	34
August	20	18
September	6	4
Total	110	100

If the weather in the month of May be mild and warm from the beginning, a better growth may be expected, amounting, as in June, to about thirty per centum. This month (May) is decidedly of great importance for the growth of the fish during the current year, for, in proportion as the fish has grown in the short space of one month, it will take more food in the following ones, as the increase of its growth and consequent wants will demand. Culturists, therefore, consider the month of May as being the most important of the whole period of the Carp's growth. The above-given calculations, of course, are limited to ponds in which no artificial feeding is resorted to, but in which there is sufficient food by reason of the good quality of the water and soil which produces it.

In small ponds, situated in parks or gardens, which possess favorable soil and river water, the increase of weight will be even a little greater if feeding is had recourse to, for such small ponds (covering only half an acre) cannot produce sufficient food themselves. On the whole, feeding is a makeshift, as will be seen presently, and which in very large ponds of more than from twenty to one thousand acres should not be made use of.

The above calculations are only admissible for Central Europe, from the Adriatic to the Baltic and the North Sea. In countries farther north, as in Sweden, the growth of the Carp is less, as, on the contrary, in more southern countries than Central Europe, for instance in Illyria, Dalmatia, Southern Italy, Southern Spain, and partly, also, Southern France, the result is more favorable still. There a milder and warmer climate, an early spring, a very warm summer and autumn, and a late winter, which, in addition, is mild and short, combine to exercise a favorable influence upon the thriving condition of the fishes. In these warm climates the fish becomes lively at a much earlier season, if it does at all pass the winter in that lethargic state, without taking any food, than it does in the countries of the northern parts of Central Europe.

REPRODUCTION.—The pond Carp of Central Europe generally leaves its winter retreat when the rays of the spring sun have warmed the water thoroughly, while at the same time it begins to seek for food at a somewhat earlier period in rivers and lakes. At the beginning of the month of March the eggs have developed themselves considerably in the body of the fish, and it only needs a few weeks of warm weather to bring about the spawning season. This commences in the middle of May in such lakes and ponds of Central and Northern France, Southern Germany and Austria, as have a warm situation and are sheltered from the cold winds. It continues in some localities throughout June and July, and sometimes, in more elevated situations, until August, as, for instance, in Franconia and Upper Bavaria. The spawn of so late a season, however, is scarcely fit for breeding purposes, as the fish cannot grow much more during the short space of warm weather. It remains very small and suffers greatly from the ensuing winter weather, and is easily

dwarfed at that time. The spawning of the individual fish does not take place all at once. Days and weeks may pass before it will have left the last egg to the care of nature. At times, upon the setting in of rainy, cool weather during this period, it will be interrupted, but reassumed as soon as the temperature grows warmer again. Culturists altogether dislike cold weather at this time, as not only the eggs but the young fry also suffer much from it. Wet, cold summers are no more profitable to the culturists of Carp than to the agriculturist. In the southern part of Europe the spawning season commences at an earlier date than in Central Europe. In Sicily, in the neighborhood of Palermo, where there are some private ponds, the Carp begins to spawn at the commencement of the month of April. This is said to be the case also in the French province of Constantine, Algeria, Africa.

The abundance of eggs in the Carp is very great, and it is this circumstance which will explain its extraordinary increase in the natural waters. A fish weighing from four to five pounds contains, on an average, 400,000 to 500,000 eggs. Other statements figure still higher. I not only made calculations myself formerly, repeating them in 1876 on a female Mirror Carp, which I obtained from the environs of Gunzenhausen, Bavaria, and which, curiously enough, at the end of November, was entirely ripe, but I also obtained statements from culturists on whom I could depend. The calculation I made in the following manner: After freeing the eggs from all the fat and the inclosing membrane, and after having washed them in alcohol, I counted off exactly 1,000 of them; these I weighed, and according to the result I deduced the number of the whole. In the somewhat longer-bodied Scale Carp, I generally found comparatively more eggs than in a Mirror or Leather Carp, though all were of equal age and weight.

During the spawning season an appreciable change takes place in the male, protuberances, like warts, appearing on the skin of the head and back, and disappearing upon the expiration of that period. This is a peculiarity with most of the cyprinoids. Some time before the spawning season sets in, the falling out of the pharyngeal teeth takes place; these grow anew every year.

Some days before spawning the fish show an increased vivacity; they rise more often from the depths below to the surface. Two or three or more of the male fish keep near the female; the latter swims more swiftly on a warm, sunny morning, keeping mostly close to the surface, followed by the males. This is called "*streichen*"=running-spawning, and is more frequent in warm than in windy and rainy weather. The female prefers spots which are overgrown with grasses and other kinds of aquatic plants, such as *Utricularia*, *Nymphea*, and *Alisma*. The male fishes follow close to the very water's edge, as far as the diminished depth will allow them. They lose all their timidity and precaution, so that they may be taken quite easily. They lash the water in a lively way, twisting the posterior portion of the body energetically, and shooting through the water near its surface with short, tremulous movements of the fins. They do so in groups of two or three males to one female fish, and forming an almost compact mass. This is the moment when the female drops the eggs, which immediately are impregnated by the milter. As this process is repeated several times, the female drops probably only from four hundred to five hundred eggs at a time, in order to gain resting time, so that it will require days and weeks before it has given up the last egg.

The eggs of the Carp are adhesive, not detached, like those of the *Salmonidæ*, these latter lying loosely on the ground, while the former adhere in lumps to the object upon which they have fallen. As soon as the egg has left the body of the fish it swells up a little, the mucus, which surrounds it, serving as a means to fasten itself upon some aquatic plant, stone, or brush-wood. Those eggs which have no such object to cling to are lost. I found numerous eggs on the reverse sides of the leaves of the *Nymphaceæ* and their stems, the *Phellandrium* and *Utricularia*, but the

greater number of them I discovered on the *Festuca fluitans*, which among fishermen is known generally by the name of "water-grass." Its narrow, long, strap-shaped, thin leaves spread softly over the water's surface, as also its numerous branches in the water afford to the fish the sought-for opportunity to deposit its eggs upon its tender leaves. The seeds of this grass are an excellent food for the Carp. This may be regarded as a useful indication to be acted upon in the construction of ponds.

The eggs will develope themselves quickly if assisted by warm weather. As early as the fifth or sixth day the first traces of dusky spots, the eyes, will be visible, and toward the twelfth, or at the latest the sixteenth day the little embryo fish will break through its envelope. This rapid development takes place only in shallow, thoroughly-warmed ponds, or in such as were expressly constructed for hatching, and called breeding ponds. If these ponds are deep, and consequently their water is colder, the hatching process may require as many as twenty days. In from three to five days the young fish has absorbed the yolks, and seeks its food. If the breeding pond be productive enough to furnish the necessary food for so many young fishes, these will grow very rapidly. I shall return to this subject hereafter.

I remarked above that the Carp prefers stagnant or slowly-running water with a muddy bottom, and that it lives upon vegetable as well as animal food, aquatic plants, seeds, worms, and larvæ of water insects; it is therefore no fish of prey. It does not attack other fishes, and has no teeth in its mouth, but only in the throat, and is, on account of its harmlessness, an excellent fish for the culturist, as well as for stocking large lakes and rivers in general.

GROWTH AND SIZE.—Its growth differs, according as the fish inhabits cold or warm water, a river, lake, or pond, finding plentiful food therein, or being fed. An additional factor is the quality of the soil, whether muddy or stony. In cold water, or such as has a stony ground, the Carp will not progress favorably. For this reason, the statements concerning its normal size, attained to in a certain given time, differ widely. Very naturally, it will exercise an extremely great influence upon the thriving of the fishes whether the pond contains a great number or only a few of them; whether it is overstocked, as culturists term it, or whether there are only a proportionate number of fishes in it, according to its capability of producing food. Other considerations remain to be mentioned, namely, Is the pond provided with supplies from brooks falling into it, or are the fishes to be fed? The latter course is almost indispensable in the culture of trout. The expenses incurred in this case diminish the income of the culturist; if not resorted to, the result will be the same, as the value of the fish will be smaller. This feeding is needless with the Carp, if it be cultivated judiciously in suitable ponds, and for this reason alone the culture of the Carp is preferable to that of the trout.

In rivers and lakes it grows larger, although the same fish; for the reason, probably, that in a larger space, which at the same time yields more sheltered retreats, it escapes from the pursuit of man more easily than in regular artificial ponds, and finds more plentiful supplies of food.

The question of the species, or I would rather say the race, is of great moment, particularly in respect to carp-culture in ponds.

A favorable result may be expected from the culture of this fish wherever the necessary water is to be found, be it in the north or south, and that, too, as well in ponds as in open lakes and rivers.

The normal weight which a Carp may attain to in three years, whether it be Scale Carp, Mirror Carp, or Leather Carp, is an average of from three to three and one-fourth pounds; that is, a fish which has lived two summers, consequently is eighteen months old, will weigh two and three-fourths to three and one-fourth pounds the year following. The growth may turn out to be

even more favorable in a warm year, or if only a few fishes have been placed in a pond, as we shall see farther on, in the chapter treating of pond-culture and the operations of the culturist.[1]

Carps may reach a very advanced age, as specimens are to be found in Austria over one hundred and forty years old. The increase in length only continues up to a certain age, but its circumference will increase up to its thirty-fifth year.

I have seen some common Carp in the southern parts of Europe—in the lowlands of Hungary, Servia, Croatia, Wallachia, as also in Moldavia and the Buckowina—which weighed from thirty to forty pounds and more, measuring nearly three and one-half feet in length by two and three-fourths feet in circumference.

Old men, whose credibility and truthfulness could not be doubted, assured me and gave the most detailed accounts of the capture of this species of fish in former years, giants, which weighed from fifty to sixty pounds, and which they had seen themselves. During the Crimean war in 1853, a French engineer officer, stationed at Widdin, on the Danube, in Turkey, killed a Carp by a bullet-shot, some distance below the city; this fish weighed sixty-seven pounds. I had some of its scales in my possession, of which each had a diameter of two and one-half inches. Their structure indicated to a certainty that the age of this fish could be no more than twenty-four years at the most. It is a well-known fact that two large Carps, weighing from forty-two to fifty-five pounds, were taken several years ago on one of the Grand Duke of Oldenburg's domains in Northern Germany. They have been kept in some particularly favorable water, productive of plentiful food, and had been used as breeding fishes. These two specimens might, from their size, be calculated to be comparatively very aged fishes; it was proved that they were only fifteen years old. If we may credit the chronicles kept centuries ago by old families, and especially by the monks, who had taken possession of all the best localities along the banks of the beautiful blue Danube, then still greater giants had been caught, and that in the waters of the Danube itself. A chronicle of the monastery of Mölk, in Austria, refers to a Carp weighing seventy-eight pounds, which had been captured on Ascension Day in 1520. Another record speaks of a Carp which had been taken in the third decennium of the present century in the lake of Zug, in Switzerland, and which weighed ninety pounds. These giants are certainly only wonderful exceptions, and have become celebrated through the scarcity of such occurrences, but still these facts are encouraging illustrations that it is possible for such large specimens to grow up in favorable waters. All the countries where these large fishes have been found, and which are situated between the Black, the North, and the Baltic Seas, are pretty nearly such as have a late spring and a long, cold winter. Near Widdin the Danube has been frozen repeatedly. There the Carp passes from five to seven months in its winter sleep, during which it does not grow. If this fish thrives so well in the countries which have such a very cold winter (on an average they have the same winter temperature as Boston, Chicago, Milwaukee, Pittsburgh, Philadelphia, New York, Baltimore and Saint Louis), where the rivers have not enough food for these fishes by far, their level being regulated by dams, which are a subject of constant complaint to the fishermen, how much more would they thrive in the waters of this country with their great riches of food? But if we take into account the rivers of the mild South and Southwest of the United States, what success may not be expected for this fish in those regions?

If the Carp finds food in superfluity it will grow much more rapidly than the above statement indicates. This gives an increase of from three to three and one-fourth pounds in one year and six months; but this is only the normal one, the food consumed being of an average amount. If the fish obtain food very plentifully it will grow more rapidly. In this case, again, it is to be consid-

[1] Report of the United States Fish Commision, pt. iv, p. 876 *et seq.*

ered that the waters of the milder climates of this country possess this advantage, scarcely to be judged of or estimated at its proper value as yet, that the fish may be able during three-quarters of the year, or even the whole year round, to take food, and will omit the lethargic winter sleep conditioned by the cold winter. There is scarcely a comparison to be made, so far as the Carp is concerned, between the rivers of this country, so richly supplied with food, which it will not be compelled to seek under a constant strife for existence, and the much poorer waters of the Rhine, Elbe, Rhone, etc. In the waters of its native country, in Central Europe, after its first awakening from the long winter sleep, it seeks most diligently the contents of the seeds of the *Nuphar luteum* and *Nymphæa alba* (the yellow and white water-lily), the *Phellandrium aquaticum*, *Festuca fluitans*, etc. The waters of the United States abound in all these plants and numerous others the seeds of which will serve the fish as food; for instance, the wild rice (*Zizania aquatica* and *Z. fluitans*), the well known Tuscarora rice or "water-oats" with its great riches of seeds, and many others, which will yield food profusely, and which European waters do not possess, thus giving a great advantage to the American carp culturist. And then there is the culture of fish in ponds. There are culturists in Central Europe who, wishing to see the fish grow more rapidly, take the trouble to feed them with soaked barley, which they occasionally throw out in different places, and by doing so they have had a very full success, the fish growing larger, that is, more quickly than when not thus fed. By introducing the above-named wild or natural water plants in carp ponds they will be perpetuated, and the grains which have fallen to the bottom of the water will form an ample article of food for the first spring days, if we do not prefer to give them the almost worthless offal of the slaughter-houses. I do not advocate the so-called artificial feeding of this fish where the ponds themselves yield food in ample abundance, a consummation toward which the Tuscarora rice will largely contribute.

Let us once more consider the fact of its extraordinary increase of weight of about one hundred and ten per centum in the exceedingly short space of four months, for during the cold winter time, when ice thickly covers rivers and lakes, nature banishes it into its temporary tomb which it chooses and digs for itself, to hold its winter sleep in. This fish needs from fifteen to eighteen months of growth to gain, according to a low estimation, the weight of three pounds without being fed. But much more satisfactory results are frequently arrived at when favorable circumstances combine and when it will reach a greater weight. There are some culturists who obtain in the same space of time fishes of four pounds' weight; of course they possess warmly situated ponds which thaw very early in spring, and perhaps they assist nature in some degree by feeding the fishes. I have done so myself in two successive years, which were exceptionally warm, when I fed the fishes with the almost worthless malt refuse or "grains." They increased visibly and attained to the above-mentioned weight in the same space of time.

This fifteen to eighteen months of the actual time of growth transpires during a period of three years and six months, as intervening months of winter sleep are to be included, during which the growth is interrupted.

I will not recur to what this fish promises to become in the milder regions of the South, where neither ice-bound water nor cold temperatures force upon it the lethargy of the winter sleep, where it will have the longer space of from eight to ten months, or may be the whole year, including the mild winter, for the most vigorous and rapid development, not, as in Europe, the sparingly allotted four or five months. It is not to be doubted that the Carp will arrive at the weight of from two and three-fourths to four pounds in one year in those warm climates, when in colder regions it requires two years and six months. I do not think that I am mistaken in this; I am ready to stand by this assertion, which the future will surely verify.

For a full account of the methods of culture the inquirer is referred to the Report of the United States Commission of Fisheries, part iv, 1875–'76, pp. 876–900, and to other papers in the subsequent reports. At the time of the publication of this volume the progeny of the three hundred and forty-five young Carp brought over from Germany in May, 1877, have been distributed to all parts of the United States, and the Carp is almost as familiar to our people as is any other kind of domesticated animal.

"The Carp," writes Jordan, "has been extensively introduced into California and Oregon, and it has thriven admirably. In many parts of California there are now carp ponds, but they are most numerous, and perhaps most profitable, in Sonoma County."

189. THE CATFISH FAMILY—SILURIDÆ.

By David S. Jordan.

The Catfishes abound in all the fresh waters of the United States east of the Rocky Mountains. The species of the three genera, *Ictalurus*, *Amiurus*, and *Leptops*, which constitute the bulk of the family as represented in North America, all reach a length of from one to five feet, and are all food-fishes of more or less importance. One of the Catfishes, *Ictalurus ponderosus*, is our largest fresh-water fish, weighing upwards of one hundred and fifty pounds, and two of the others, *Leptops olivaris* and *Ictalurus nigricans*, reach a very considerable size.

The Catfishes are voracious and indiscriminate feeders, any kind of animal substance, living or dead, being greedily swallowed by them. They are also (especially the species of *Amiurus*) extremely tenacious of life, living for a long time out of water, and being able to resist impurities in the water better than any other of our food-fishes. They spawn in spring, and the female fish keeps a watch over the school of young, much as a hen takes care of chickens. The Catfishes are especially adapted for stocking ponds and sluggish streams with muddy bottoms, or which become partly dry in summer, bodies of water not suited for the more aristocratic trout and bass.

The species of the genus *Ictalurus*—known as "Channel Cats" are much less hardy than the other Catfishes, and do not thrive well except in river channels. Any water which does not dry up absolutely to the bottom in summer will suffice to nurture the common small Catfishes.

The flesh of all the Catfishes is of fair quality, not delicate nor tender, but of good flavor. The Channel Cats have whiter meat than the ordinary small Catfish, but the flesh is drier, and the latter are usually preferred.

The common Channel Cat—Ictalurus punctatus.

The Channel Cat or Blue Cat abounds in all the larger Western and Southern streams, living in the river channels. It reaches a weight of five to ten pounds and is readily salable, but its flesh is not better than that of its less attractive relatives. It takes the hook readily. This species is abundant in the Saint John's River, Florida. In 1878 many were taken near the bar at Mayport in brackish water. For table use they are much more highly esteemed than the Mud Catfish.

Great Mississippi Cat—Ictalurus ponderosus.

This species, the largest of our Catfish, is found in the Mississippi, and probably in its larger tributaries, where it reaches a weight of about one hundred and fifty pounds. Little distinctive is known of its habits, which probably agree with those of the next species.

The Great Lake Catfish; Flannel-mouth Cat (the young)—Ictalurus nigricans.

This species, the most abundant of the large Catfishes, abounds in the Great Lakes and in the larger streams of the West and South as far as Florida. It reaches a weight of fifty to one hundred pounds, perhaps more. In all the markets of the region where found it is one of the most important species, and its flesh, which can be cut in "steaks" like halibut, is generally esteemed. Nothing distinctive is known of its breeding habits or rate of growth. Professor Goode remarks: "I have observed frequently enormous specimens of this species in the Saint John's River, where they are called Mud Cats."

The Channel Cat of the Potomac—Ictalurus albidus.

The White Catfish of the tributaries of the Chesapeake Bay is very abundant in the Susquehanna and Potomac Rivers, and forms an important part of the fish supply of the Washington market. It reaches a weight of two to five pounds, being much smaller than the preceding species, which it resembles.

The Horned Pout—Amiurus nebulosus.

The common "Horned Pout," "Bull-head," "Bull-pout," or "Minister" of the Northern and Eastern States is the most generally abundant and familiar representative of this family. It reaches a length of about eighteen inches and rarely exceeds three or four pounds in weight, while the majority of those seen in the markets are still smaller. It is probably the hardiest of all our fresh-water fishes, thriving in any waters, but preferring those which are quiet and shaded. Numerous other species very similar to this occur in our fresh waters.

The Bull-head has been introduced from the Schuylkill into the Sacramento and San Joaquin Rivers in California. It has there very rapidly multiplied, and is now common in all the sloughs and bayous of the lower courses of these rivers. As a food-fish it is not very highly valued by the Californians, most of those brought to market being taken by the Chinese.

The Mud Cat—Leptops olivaris.

The "Mud Cat," "Yellow Cat," "Goujon," or "Bashaw" is found in all the large rivers of the West and South. It reaches a weight of at least fifty pounds. It is found only in the larger streams, swimming near the bottom. It is less attractive in its appearance than the other Catfishes, but we are not aware that its flesh is inferior to that of the others. This species, and other of the larger Catfishes, are often caught by "jugging," the bait being attached to a jug filled with air, which will in time tire out the fish and bring it to the surface.

The Stone Cat—Noturus flavus.

This species reaches a length of about a foot; the other Stone Cats (*Noturus*) are still smaller, and none of them can be considered as food-fishes.

The Gaff-topsail Catfish—Ælurichthys marinus.

This species, which ranges from Cape Cod to Florida, is found chiefly in brackish water. It is not uncommonly taken at Arlington, Florida, and Empire Point. It is known here and at Pensacola as the "Sea Cat," and at Brunswick, Georgia, as "Gaff-topsail," in allusion to the shape of the first dorsal fin. According to Mr. H. S. Williams, it is abundant in the Indian River. It is common also along the Gulf Coast, but is nowhere valued as food. Many of the fishermen believe this species to be viviparous. Mr. S. C. Clarke, writing from New Smyrna March 31, 1874, remarks: "They have eggs in them as large as cherries."

The Salt-water Catfish—Arius felis.

The Salt-water Catfish is found along the coasts of the Gulf of Mexico to as far north as Cape Hatteras. In the first volume of the Proceedings of the United States National Museum, p. 278, is an interesting account of its breeding habits, as observed by Prof. N. T. Lupton. The species spawns there in July, and the parent (sex not stated) carries the eggs in its mouth. Silas Stearns says of this fish:

"The Salt-water Catfish is very abundant everywhere on the Gulf coast. It is found on the sea-beaches, the shores and bottoms of bays and bayous, and even some distance up fresh-water streams. It is a bottom-loving fish, feeding upon worms and small crustaceans chiefly, but will readily eat anything else—fish, flesh, or fowl, dead or alive. As the pest of these waters, it is ever present and never welcome. It breeds in the summer, in June, July, and August. The spawn is deposited in the depression in the sand and impregnated with the milt. One of the parent fish then takes the eggs in his mouth and by some movement fixes them against the gills, or between the leaves of the gills. The eggs are carried in this position until the embryo fish are hatched and have become perfect and able to care for themselves. The eggs when full size resemble white grapes; they are large and clear. Sometimes the parent fish's jaws are much distended by the eggs and young inside and its appearance is comical.

"The Catfish emits a grunting noise (similar, although louder, to several fishes of this coast—the grunt, drum, mademoiselle, croaker, etc.), which comes, I believe, from the swimming bladder. This noise, when there are many fish present and all else is still, is very annoying, and I have passed more than one wakeful night from hearing it on the Southern coast, where the fish were swimming under my boat. The Catfish will always take the hook, and is not at all particular as to the kind of bait; attains a weight of ten or twelve pounds, though the average is much less. It is seldom eaten except as a last resort for fresh food; it is, however, quite palatable. When caught it is almost invariably mangled and consequently thrown away."

190. THE MORAYS—MURÆNIDÆ.

On our Southern coasts are several species of eel-like fishes belonging to this family. On account of their sharp teeth and strong jaws they are rather dreaded by the fishermen, who fear their bites. Some species, however, are here, as in various parts of the West Indies, in considerable demand for food. The most important species is the Speckled Moray, *Sidera ocellata*, which is occasionally brought to the Key West markets.

California Conger Eel—Sidera mordax.

"This species," writes Jordan, "is always known as 'Conger Eel' or 'Congeree.' It reaches a length of five feet and a weight of fifteen or twenty pounds. It is found among rocks about the Santa Barbara Islands, and southward along the coast of Lower California. About the islands it is quite common. It is remarkable for its ferocious disposition. When captured it shows fight and bites savagely, striking like a snake. Its flesh is very fat, resembling that of Anguilla, and is very palatable when fried. The skin is said by the fishermen to be 'very pizen.' This species is brought into the Los Angeles market, where it meets with a ready sale. Considerable numbers are salted and dried by the Chinese."

The Sea-snakes (*Ophichthys ocellatus*, *O. chrysops*, etc.) are occasionally seen on the fishing-smacks in the Gulf of Mexico, having been obtained from the stomachs of large groupers and snappers, with which it is a favorite food. Stearns has obtained specimens at Pensacola caught with hook and line on the snapper banks, sixty miles east of that port.

191. THE EEL—ANGUILLA VULGARIS.

CLASSIFICATION.—There is no group of fishes concerning the classification and history of which there is so much doubt as the Eel family; an infinite number have been described, but most are so badly characterized or founded on individual or so trivial characters that the majority of ichthyologists will reject them.[1]

In his "Catalogue of the Fishes in the British Museum" Dr. Günther has claimed to retain those as species which are distinguished by such characters that they may be recognized, though he remarks that he is by no means certain whether really specific value should be attached to them, remarking that the snout, the form of the eyes, the width of the bands of teeth, etc., are evidently subject to much variation. In his more recent work he remarks, "Some twenty-five species of Eels are known from the coast waters of the temperate and tropical zones."

Other recent writers have cut the knot by combining all of the Eels into three or four, or even into one, species, and it seems as if no other course were really practicable, since the different forms merge into one another with almost imperceptible gradations. In his monograph of the family of anguilliform fishes,[2] M. C. M. Dareste remarks:

"Dr. Günther has recently published a monograph of the apodal fishes in which he begins the work of reducing the number of specific types. The study of the ichthyological collection of the Paris Museum, which contains nearly all of Kaup's types, has given me the opportunity of completing the work begun by Dr. Günther, and of striking from the catalogue a large number of nominal species which are founded solely upon individual peculiarities.

"How are we to distinguish individual peculiarities from the true specific characters? In this matter I have followed the suggestions made with such great force by M. Siebold in his 'History of the Fresh-water Fishes of Central Europe.' This accomplished naturalist has shown that the relative proportions of the different parts of the body and the head vary considerably in fishes of the same species, in accordance with certain physiological conditions, and that consequently they are far from having the importance which has usually been attributed to them in the determination of specific characters.

"The study of a very large number of individuals of the genera *Conger* and *Anguilla* has fully convinced me of the justice of this observation of Siebold; for the extreme variability of proportions forbids us to consider them as furnishing true specific characters.

"I also think, with Siebold, that albinism and melanism, that is to say, the diminution or augmentation of the number of chromatophores, are only individual anomalies and cannot be ranked as specific characters. Risso long since separated the black Congers under the name *Muræna nigra*. Kaup described as distinct species many black Anguillas. These species should be suppressed. I have elsewhere proved the frequent occurrence of melanism and albinism more or less complete in nearly all the types of fishes belonging to this family, a fact especially interesting since albinism has hitherto been regarded as a very exceptional phenomenon in the group of fishes. This also occurs in the *Symbranchidæ*. I have recently shown it in a specimen of *Monopterus* from Cochin China presented to the museum by M. Geoffroy St. Hilaire.

"I must also signalize a new cause of multiplication of species; it is partial or total absence of ossification in certain individuals. This phenomenon, which may be explained as a kind of *rachitis* (rickets), has not to my knowledge been noticed, yet I have found it in a large number of specimens. I had prepared the skeleton of a Conger of medium size, the bones of which are

[1] GÜNTHER: Catalogue of the Fishes in the British Museum, viii, p. 24.
[2] Comptes-rendus of the Academy of Sciences, Paris.

flexible and have remained in an entirely cartilaginous state. Still it is not necessary to prepare the skeleton to determine the absence of ossification, for we can establish this easily in unskinned specimens by the flexibility of the jaws. It is very remarkable that this modification of the skeleton is not incompatible with healthy existence, and that it does not prevent the fish in which it is found from attaining a very large size.

"Those fishes in which ossification is absent are remarkable by reason of the great reduction of the number of teeth, which, although the only parts which become hard by the deposit of calcareous salts, remain however much smaller than in individuals whose skeletons are completely ossified.

"We can thus understand how such specimens could present characters apparently specific, and that they should have been considered by Kaup as types of new species. These considerations have led me to reduce, on an extensive scale, the number of species in the family.

"So, in the genus *Anguilla*, I find but four species: *Anguilla vulgaris*, occurring throughout the northern hemisphere, in the New World as well as the Old; *Anguilla marmorata* and *A. mowa* of the Indian Ocean, and *Anguilla megalostoma* of Oceanica.

"There are at least four distinct types, resulting from the combination of a certain number of characters; but the study of a very large number of specimens belonging to these four specific types has convinced me that each of these characters may vary independently, and that consequently certain individuals exhibit a combination of characters belonging to two distinct types. It is therefore impossible to establish clearly defined barriers separating these four types.

"The genus *Anguilla* exhibits, then, a phenomenon which is also found in many other genera, and even in the genus *Homo* itself, and which can be explained in only two ways: Either these four forms have had a common origin and are merely races, not species, or else they are distinct in origin, and are true species, but have been more or less intermingled, and have produced by their mingling intermediate forms which coexist with those which were primitive. Science is not in the position to decide positively between these alternatives."[1]

It is the disposition of American ichthyologists, at least, to accept the views of Dareste, and to consider all the Eels of the northern hemisphere as members of one polymorphic species. Günther is inclined to recognize three species in North America: one the common Eel of Europe, *Anguilla vulgaris;* one the common American Eel, *Anguilla bostoniensis* (*rostrata*), which he finds also in Japan and China; and the third, *Anguilla texana*, described and illustrated by Girard, in the "Report of the United States and Mexican Boundary Survey," under the name of *A. texana*, which, he remarks, is scarcely specifically distinct from *A. bostoniensis*, from which it differs only in the greater development of the lips, a distinction which seems to be imaginary. The distinction between *A. bostoniensis* and *A. vulgaris*, as stated by him, consists chiefly in the fact that the dorsal fin is situated a little farther back upon the body, so that in the former the distance between the commencement of the dorsal and anal fin is shorter than the head, while in the latter it is equal to or somewhat longer than it. This character does not appear to be at all constant.

GEOGRAPHICAL DISTRIBUTION.—Assuming the specific identity of the Eels of the Old and the New World, the distribution of the common Eel may be defined somewhat as follows: In the rivers and along the ocean shores of Eastern North America, south to Texas and Mexico, and north at least to the Gulf of Saint Lawrence, but absent in the waters tributary to Hudson Bay, the Arctic

[1] These conclusions of Dareste have a very mediæval ring. "Science" is certainly in the position to say that neither of these hypotheses can be true. From the stand point of modern zoology, the common origin of the species of Anguilla admits of no reasonable doubt. Between the four "species" of Dareste and their less sharply defined races, no permanent difference exists. The name "species" certainly cannot be refused to forms having supposably a common origin.—J.

Sea and the Pacific; present in Southern Greenland (?) and Iceland, latitude 65° north; on the entire coast of Norway, from the North Cape, latitude 71°, southward; abundant in the Baltic, and in the rivers of Russia and Germany which are its tributaries, and along the entire western and Mediterranean coasts of Europe, though not present in the Black Sea, in the Danube or any of its other tributaries, or in the Caspian; occurring also off Japan and China and Formosa; also in various islands of the Atlantic, Grenada, Dominica, the Bermudas, Madeira, and the Azores.

HABITS.—The habits of the Eel are very different from those of any other fish, and are as yet but little understood.

"This, so far as we know," writes Professor Baird, "is the only fish the young of which ascend from the sea to attain maturity, instead of descending from the fresh to the salt water. Its natural history has been a matter of considerable inquiry within a few years, although even now we are far from having that information concerning it that would be desirable, in view of its enormous abundance and its great value as a food-fish.

"The eggs of the Eel are for the most part laid in the sea, and in the early spring, the period varying with the latitude, the young fish may be seen ascending the rivers in vast numbers, and when arrested by an apparently impassable barrier, natural or artificial, they will leave the water and make their way above the obstruction, in endeavoring to reach the point at which they aim. Here they bury themselves in the mud and feed on any kind of animal substance, the spawn of fish, the roes of shad, small fish, etc. At the end of their sojourn in the ponds or streams they return to the sea, and are then captured in immense numbers in many rivers in what are called fish-baskets. A V-shaped fence is made, with the opening down-stream into the basket, into which the Eels fall, and from which they cannot easily escape. This same device, it may be incidentally stated, captures also great numbers of other fish, such as shad, salmon, and other anadromous fish, to their grievous destruction.

"As might be expected, however, the Falls of Niagara constitute an impassable barrier to their ascent. The fish is very abundant in Lake Ontario, and until artificially introduced was unknown in Lake Erie. At the present time, in the spring and summer, the visitor who enters under the sheet of water at the foot of the falls will be astonished at the enormous numbers of young Eels crawling over the slippery rocks and squirming in the seething whirlpools. An estimate of hundreds of wagon-loads, as seen in the course of the perilous journey referred to, would hardly be considered excessive by those who have visited the spot at a suitable season of the year.

"The economical value of the Eel as a food-fish has been well established, and it is now greatly sought after for introduction into the localities where, for some physical or other reason, it is unknown. The advantages, as summed up by a German writer, are, first, that an Eel will live and grow in any water, however warm, and whatever be the general character of the bottom, though it prefers the latter when muddy and boggy; second, the Eel requires no special food, but devours anything living or dead; it is an excellent scavenger, feeding upon dead fish, crabs, etc., as well as upon any living prey it can secure; third, but few conditions can interfere with its development, while it grows with very great rapidity, being marketable at the age of three years; fourth, the young, on account of their hardiness, can be transported in a crowded condition, and to any distance, with very little risk of destruction. These considerations are, in the main, well established, and there is no question but that the Eel can be introduced in many waters to advantage, supplementing the earlier inhabitants. It has been planted in the waters of the Upper Lakes and the Mississippi River; in the latter they have reached an advanced development. It is, however, a very undesirable inmate of rivers in which fish are taken by means of gill-nets, the destruction of shad and herring in the waters of the Susquehanna and others farther south

being enormous. It is not unfrequent that, when a gill-net is hauled up, the greater part of the catch consists simply of heads and backbones, the remainder being devoured by myriads of Eels in the short time the net is left out. The spawning shad are considered by them a special delicacy, and are found emptied at the vent and completely gutted of the ovaries. Sometimes a shad, apparently full, is found to contain several Eels of considerable size. They do not seem to be very destructive of living fish of any magnitude, although the young fry are devoured with gusto."[1]

In describing the geographical distribution of the Eel it was stated that it occurs in the rivers and along the ocean shores of North America. This being the case, as might be supposed, there are many inland lakes and streams of the United States in which this fish does not occur; for instance, the chain of the Great Lakes above Niagara Falls, and the upper waters of other streams in which there are considerable obstructions. The cutting of canals in various parts of the country has, however, produced a great change in their distribution; for instance, it is stated by Mitchill[2] that Eels were unknown in the Passaic above the Great Falls until a canal was cut at Paterson, since which time they have become plentiful in the upper branches of that river. They have also been placed in many new localities by the agency of man. Concerning this Mr. Milner remarks:

"The Eel (*Anguilla bostoniensis*), appreciated in some localities and much vilified in others, is another species that has been frequently transplanted. It is pretty evident that it never existed naturally in the chain of Great Lakes any higher up than Niagara Falls, although specimens have been taken in Lakes Erie and Michigan. Their existence there is with little doubt traceable to artificial transportation.

"A captain of a lake vessel informed me that it was quite a common thing some years ago to carry a quantity of live Eels in a tub on the deck of a vessel while on Lake Ontario, and they were often taken in this manner through the Welland Canal. He said that it was a frequent occurrence on his vessel when they had become tired of them, or had procured better fishes, to turn the remainder alive into the waters of Lake Erie.

"In 1871 Mr. A. Booth, a large dealer of Chicago, had an Eel of four pounds' weight sent him from the south end of Lake Michigan, and a few weeks afterward a fisherman of Ahnapee, Wisconsin, nearly two hundred miles to the northward, wrote him that he had taken a few Eels at that point. It was a matter of interest to account for their presence, and a long time afterward we learned that some parties at Eaton Rapids, Michigan, on a tributary of the lake, had imported a number of Eels and put them in the stream at that place, from which they had doubtless made their way to the points where they were taken. The unfortunate aquarium-car in June, 1873, by means of the accident that occurred at Elkhorn River, released a number of Eels into that stream, and about four thousand were placed by the United States Commission in the Calumet River at South Chicago, Illinois, two hundred in Dead River, Waukegan, Illinois, and thirty-eight hundred in Fox River, Wisconsin."[3]

They have since been successfully introduced into California.

LIFE HISTORY.—Concerning the life history of the Eel much has been written, and there have been many disputes even so late as 1880. In the article upon ichthyology, contributed to the Encyclopedia Britannica, Günther writes:

"Their mode of propagation is still unknown. So much only is certain, that they do not

[1] MS. note by Professor Baird.
[2] Transactions Literary and Philosophical Society New York, i, p. 48.
[3] Report United States Fish Commission, part ii, 1874, 526.

spawn in fresh water; that many full-grown individuals, but not all, descend rivers during the winter months, and that some of them at least must spawn in brackish water or in deep water in the sea; for in the course of the summer young individuals from three to five inches long ascend rivers in incredible numbers, overcoming all obstacles, ascending vertical walls or flood-gates, entering every larger and swollen tributary, and making their way even over *terra firma* to waters shut off from all communication with rivers. Such emigrations have long been known by the name '*Eel-fairs*.' The majority of the Eels which migrate to the sea appear to return to fresh water, but not in a body, but irregularly, and throughout the warmer part of the year. No naturalist has ever observed these fishes in the act of spawning, or found mature ova; and the organs of reproduction in individuals caught in fresh water are so little developed and so much alike, that the female organ can be distinguished from the male only with the aid of a microscope."

MIGRATIONS OF EELS.—In attempting to review this subject I am sure I cannot do better than to translate at length a communication just received from my friend Dr. Berthold Benecke, professor in the University of Königsberg:

"The coloration of Eels varies greatly not only in different localities, but in the very same places: the back may be dark blue or greenish black; the sides, lighter blue or green; the belly, white; sometimes the back is only slightly darker than the sides; sometimes there are olive-green individuals with a golden-yellow band upon their back, sometimes they are entirely golden-yellow, and, very rarely, entirely white. The Eel lives in deep, quiet waters with muddy bottom; it burrows out holes and tunnels in which it rests quietly during the day, while at night it comes out in search of food. From the deck of a steamer passing through rivers or canals one may see upon the banks, which are laid bare by the waves produced by the motion of the vessels, numerous Eels with half of their bodies projecting from their lurking holes.

"The Eel feeds upon all kinds of small water animals, and may be found on the spawning places of other fish in great troops, going there for the purpose of feeding upon the eggs. They feed also upon crabs at the period when they are shedding their shells, and have in many localities in Germany completely exterminated them. Since the Eel is everywhere known as a greedy robber, many accounts have been given of their wanderings, in which they have made their way into the pea-patches to feed upon pease. The oldest reference of this kind is that of Albertus Magnus, who remarks in his book of animals, published at Frankfort-on-the-Main in 1545: 'The Eel also comes out of the water in the night-time into the fields, where he can find pease, beans, or lentils.' This statement was contradicted in 1666 by Baldner,[1] who writes concerning the Eel: 'They eat fish, do not come on the land, and do not eat pease, but remain in the water always, and are nocturnal animals.'

"Forthwith, new statements were made which tended to show the actuality of the wanderings of the Eels in the pea-patches. For instance, Bach, in his 'Natural History of East and West Prussia,' published in 1784, maintained that Eels frequently were caught in the pea-patches in the vicinity of the water, where they fed upon the leaves, or, according to other accounts, upon the pease themselves, and continues: 'These movements explain the paradoxical fact that in Prussia and Pomerania fish have been caught upon dry land by the use of the plow, for the peasants, in warm nights when the Eels are in search of the pease, towards morning when it is not yet day make furrows with the plow between them and the water, and these are the nets in which the

[1] Recht natürliche Beschreibung und Abmahlung der Wasser-Vögel, Fischen, vierfüssigen Thier, Insecten und Gewirm, so bey Strassburg in den Wassern sind, die ich selber geschossen und die Fisch gefangen, auch alles in meiner Hand gehabt. Leonhard Baldner, Fischer und Hagmeister in Strassburg gefertigt worden 1666. Manuscript. (Cited by von Siebold, "Süsswasserfische von Mitteleuropa," Leipzig, 1863.)

Eels are caught. Since the Eel moves with ease only upon the grass, its return to the water is cut off by the soil which has been thrown up. The peasants consider it as a sign of approaching stormy weather when the Eels come out of the water upon dry land.'[1]

"A person writes to me from Lyck: 'In storms they come out into the pea-patches, and at this time people spread sand or ashes around, and thus prevent their return.' Such tales are even now numerous in the newspapers.

"The small size of the gill-opening makes it possible for the Eel to live for a long time out of the water, and it is possible that in their wanderings over moist meadows they may find places in which there are snails and other desirable food. The explanation of their supposed wanderings over the pea-patches is, that the Eels, which have been found at different times in the fields or meadows, have been lost by poachers, who threw them away in their flight. Many times dead Eels have been found upon meadows over which they have swam, the meadows being flooded, and, in spite of the nearness of the water, have afterwards been unable to return to it.

"Although the activity and tendency among the young Eels to wander is very great, yet we cannot believe in the wandering of adult Eels over wide stretches of land. According to Spallanzani, in Comacchio, where for many centuries an eel fishery of immense extent has been carried on, although these fish are found in numerous ponds and lagoons, the fishermen have never yet seen an Eel wandering over the land; and once when, on account of the drying up of the water, the Eels died by the thousand, not one of them made the attempt to escape by a short journey overland into the neighboring lake or into the river Po.

"The Eel occurs in all our waters, with the exception of small rapid brooks. The fishermen distinguish many varieties based upon the differences in the form of the head or color and the varying proportions in the length of the body and tail; and the older ichthyologists have followed their opinions without sufficient reason.

"By rapid growth the Eel attains the length of twenty-four to thirty inches, and often a greater size. On account of their fat, which is very highly flavored, and the absence of bones, they are everywhere valued, and are caught in various ways. The most profitable method of capture is in eel-weirs and eel-baskets, and in traps by the use of nets, and on hooks they are also caught in great quantities. In winter many Eels are taken with spears on the shelving shores where they lie buried in the mud in a state of torpidity. In this fishery very often more are wounded than captured, and, in addition to the large Eels, great quantities of small ones are taken."

ANCIENT BELIEFS CONCERNING THE REPRODUCTION OF THE EEL.—The reproduction of the Eel, continues Benecke, has been an unsolved riddle since the time of Aristotle, and has given rise to the most wonderful conjectures and assertions. Leaving out of question the old theories that the Eels are generated from slime, from dew, from horsehair, from the skins of the old Eels, or from those of snakes, and the question as to whether they are produced by the female of the Eel or by that of some other species of fish, it has for centuries been a question of dispute whether the Eel is an egg-laying animal or whether it produces its young alive; although the fishermen believe that they can tell the male and female Eels by the form of the snout. A hundred years ago no man had ever found the sexual organs in the Eel.

Jacoby has remarked that the Eel was from the earliest times a riddle to the Greeks; while ages ago it was known by them at what periods all other kinds of fishes laid their eggs, such discoveries were never made with reference to the Eel, although thousands upon thousands were yearly applied to culinary uses. The Greek poets, following the usage of their day, which was to attribute to

[1] A live and active Eel, a few days since, was dug out from a depth of five feet in the soil of Exeter, New Hampshire.—*Gloucester Telegraph*, October 26, 1870.

Jupiter all children whose paternity was doubtful, were accustomed to say that Jupiter was also progenitor of the Eel.

"When we bear in mind," writes Jacoby, "the veneration in which Aristotle was held in ancient times, and still more throughout the Middle Ages—a period of nearly two thousand years—it could not be otherwise than that this wonderful statement should be believed, and that it should be embellished by numerous additional legends and amplifications, many of which have held their own in the popular mind until the present day. There is no animal concerning whose origin and existence there is such a number of false beliefs and ridiculous fables. Some of these may be put aside as fabrications; others were, probably, more or less true, but all the opinions concerning the propagation of the Eel may be grouped together as errors into three classes:

"I. The beliefs which, in accordance with the description of Aristotle, account for the origin of the Eel on the basis of its development not from the mud of the earth, but from slimy masses which are found where the Eels rub their bodies against each other. This opinion was advanced by Pliny, by Athenæus, and by Oppian, and in the sixteenth century was again advocated by Rondelet and reiterated by Conrad Gessner.

"II. Other authorities base their claims upon the occasional discovery of worm-like animals in the intestines of the Eels, which they described, with more or less zealous belief, as the young Eels, claiming that the Eel should be considered as an animal which brought forth its young alive, although Aristotle in his day had pronounced this belief erroneous, and very rightly had stated that these objects were probably intestinal worms. Those who discovered them anew had no hesitation in pronouncing them young Eels which were to be born alive. This opinion was first brought up in the Middle Ages in the writings of Albertus Magnus, and in the following centuries by the zoologists Leeuwenhoek, Elsner, Redi, and Fahlberg; even Linnæus assented to this belief and stated that the Eel was viviparous. It is but natural that unskilled observers, when they open an Eel and find inside of it a greater or smaller number of living creatures with elongated bodies, should be satisfied, without further observation, that these are the young of the Eel. It may be distinctly stated, however, that in all cases where Eels of this sort have been scientifically investigated, they have been found to be intestinal worms.[1]

"III. The last group of errors includes the various suppositions that Eels are born not from Eels, but from other fishes, and even from animals which do not belong at all to the class of fishes. Absurd as this supposition, which in fact was contradicted by Aristotle, may seem, it is found at the present day among the eel-catchers in many parts of the world.

"On the coast of Germany a fish related to the cod, *Zoarces viviparus*, which brings its young living into the world, owes to this circumstance its name *Aalmutter*, or Eel Mother, and similar names are found on the coast of Scandinavia."

"In the lagoon of Comacchio," continues Jacoby, "I have again convinced myself of the ineradicable belief among the fishermen that the Eel is born of other fishes; they point to special differences in color, and especially in the common mullet, *Mugil cephalus*, as the causes of variations in color and form among Eels. It is a very ancient belief, widely prevalent to the present day, that Eels pair with water-snakes. In Sardinia the fishermen cling to the belief that a certain beetle, the so-called water-beetle, *Dytiscus Roeselii*, is the progenitor of Eels, and they therefore call this 'Mother of Eels.'"

[1] It is very strange that an observer so careful as Dr. Jacoby should denounce in this connection the well-known error of Dr. Eberhard, of Rostock, who mistook a species of Zoarces for an Eel, and described the young, which he found alive within the body of its mother, as the embryo of the Eel. In Jacoby's essay, p. 24, he states that the animal described by Eberhard was simply an intestinal worm, an error which will be manifest to all who will take the pains to examine the figure.

DISCOVERY OF THE FEMALE EEL.—A scientific investigation into the generation of Eels could only begin when, at the end of the Middle Ages, the prohibition which the veneration for Aristotle had thrown over the investigations of learned men was thrown aside. With the revival of the natural sciences in the sixteenth century we find that investigators turned themselves with great zeal to this special question. There are treatises upon the generation of the Eel written by the most renowned investigators of that period, such as Rondelet, Salviani, and Aldrovandi. Nevertheless, this, like the following century, was burdened with the memory of the numerous past opinions upon the eel question, and with the supposed finding of young inside the body of the Eel.

The principal supporters of the theory that the Eel was viviparous were Albertus Magnus, Leeuwenhoek, Elsner, Redi, and Fahlberg. The naturalists Franz Redi and Christian Franz Paullini, who lived in the seventeenth century, must be mentioned as the first who were of the opinion, founded, however, upon no special observations, that the generation of the Eel was in no respect different from that of other fishes.

In the eighteenth century it was for the first time maintained that the female organs of the Eel could certainly be recognized. It is interesting that the lake of Comacchio was the starting point for this conclusion as well as for many of the errors which had preceded it. The learned surgeon Sancassini, of Comacchio, visiting an eel fishery at that place in 1707, found an Eel with its belly conspicuously enlarged; he opened it and found an organ resembling an ovary, and, as it appeared to him, ripe eggs. Thereupon he sent his find, properly preserved, to his friend, the celebrated naturalist Vallisneri, professor in the University of Padua, who examined it carefully, and finally, to his own great delight, became satisfied that he had found the ovaries of the Eel. He prepared an elaborate communication upon the subject, which he sent to the Academy at Bologna.[1]

At the very beginning there were grave questions raised as to the correctness of this discovery. The principal anatomical authority at Bologna, Professor Valsalva, appears to have shared these doubts, especially since shortly after that a second specimen of Eel, which presented the same appearance as that which was described by Vallisneri, was sent from Comacchio to Bologna. The discussion continued, and it soon came to be regarded by the scientific men of Bologna as a matter of extreme importance to find the true ovaries of the Eel. Pietro Molinelli offered to the fishermen of Comacchio a valuable reward if they would bring him a gravid Eel. In 1752 he received from a fisherman a living Eel with its belly much distended, which, when opened in the presence of a friend, he found to be filled with eggs. Unfortunately the joyful hopes which had been excited by this fortunate discovery were bitterly disappointed when it was shown that the Eel had been cunningly opened by the fisherman and filled with the eggs of another fish. The eel question came up again with somewhat more satisfactory results when, in the year 1777, another Eel was taken at Comacchio which showed the same appearance as the two which had preceded it. This Eel was received by Prof. Gaetano Monti, who, being indisposed and unable to carry on the investigation alone, invited a number of his favorite pupils, among whom was the celebrated Camillo Galvani, the discoverer of galvanism, to a council at his house. This Eel was examined by them all, and pronounced to be precisely similar to the one which had been described by Vallisneri seventy years before. It was unanimously decided that this precious specimen should be sent for exhaustive examination to the naturalist Mondini, who

[1] I fail to find any record of the publication of this paper, except that given by Jacoby, who states that it was printed at Venice in 1710, with a plate, and subsequently, in 1712, under the title "De ovario Anguillarum," in the Proceedings of the Leopold Academy.

applied himself with great zeal to the task, the results of which were published in May, 1777. The paper is entitled "De Anguillæ ovariis," and was published six years later in the Transactions of the Bologna Academy.[1] Mondini was satisfied that the supposed fish which Vallisneri described was nothing but the swimming bladder of the Eel in a diseased state, and that the bodies supposed to be eggs were simply pustules in this diseased tissue. In connection with this opinion, however, Mondini gave, and illustrated by magnificent plates, a good description and demonstration of the true ovaries of the Eel, as found by himself. This work, which in its beautiful plates illustrates also the eggs in a magnified fold of the ovary, must be regarded as classical work, and it is an act of historic justice to state that neither O. F. Müller nor Rathke, but really Carlo Mondini, was the first discoverer, describer, and demonstrator of the female organs of the Eel, which had been sought for so many centuries.[2]

Three years later, entirely independent of Mondini, the celebrated zoologist Otto Friedrich Müller published his discovery of the ovary of the Eel in the "Proceedings of the Society of Naturalists" at Berlin.[3]

The discovery of Mondini was next specially brought into prominence through Lazzaro Spallanzani. This renowned investigator, in October, 1792, went from Pavia to the lagoons of the Po, near Comacchio, for the sole purpose of there studying the eel question. He remained at Comacchio through the autumn; he was, however, unable to find anything that was new regarding the question, but in the report upon his journey of investigation he entirely threw aside the discovery of Mondini, and announced that the ovaries discovered by this authority were simply fatty folds of the lining of the stomach.[4]

"It was without doubt this absolute negative statement of such a skilled investigator as Spallanzani which for a long time discouraged further investigations on the eel question, and allowed what had already been discovered to be regarded as doubtful, and finally to be forgotten. So when Professor Rathke, of Königsberg, in his assiduous labors upon the reproductive organs of fishes, in the year 1824, described the ovaries of the Eel as two cuff-and-collar shaped organs on both sides of the backbone, and in the year 1838 described them as new, he was everywhere in Germany (and to a large extent to the present day) regarded as the discoverer.[4] The first picture of the ovary after that of Mondini, and the first microscopical plate of the egg of the Eel,

[1] De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii. Tomus VI. Bononiæ, 1783, pp. 406 *et seq.*

[2] Prof. G. B. Ercolani, of Bologna, and also Crivelli and Maggi, in their essays published in 1872, have rightly stated that Mondini's priority of discovery has been overlooked in Germany. Neither Rathke nor Hohnbaum-Hornschech nor Schlüser have mentioned his work. S. Nillson, in his "Skandinavisk Fauna," 1855, says nothing of Mondini. He mentioned as the first discoverer of the ovaries O. F. Müller, while Cuvier, in his "Histoire Naturelle des Poissons," assigns the honor rather to Rathke. Th. von Siebold is the first to announce in his work, published in 1863, "Die Süsswasserfische von Mitteleuropa," page 349, that Mondini, almost contemporaneously with O. F. Müller and independently of him, discovered the ovaries of the Eel. The error, as was discovered by Italian zoologists later than by those of Germany, arose from the fact that the announcement of Müller's discovery was printed in 1780, while that of Mondini's, which was made in 1777, was first printed in 1783.

[3] O. F. Müller: Bemühungen bei den Intestinal-würmern. Schriften, Berlin. Gesellschaft, i, 1780, p. 204.

[4] "Rathke, who first, since Mondini, has in detail described (1824, 1838, and 1850) the ovaries of the Eel, is considered by some to have recognized them; but this, however, is not true, the additions made by him to Mondini's description being to a great extent erroneous. It is not true that the transverse leaflets are wanting in the ovaries of the Eel, as he asserts in his last work, contrary to his former description, which was probably based on the law of analogy, and that thereby they are distinguished from those of the salmon and sturgeon. It is not true, what Rathke likewise asserts, that the genital opening of the Eel consists of two small canals, for I have invariably only found one, which opens in the urethra. Rathke has certainly described the eggs quite exactly, distinguishing the larger whitish ones, having a diameter of about one-fifteenth of a line, and the smaller transparent ones, with the germinal vesicle inside; but Mondini likewise says: "*innumeras sphærulas minimas, æquales, pellucidas, divisas tamen, quæ in centro maculam ostendebant, ecc. vidi,*" thus showing the true nature of the ovaries and the eggs, and contrasting them with the fatty formation and with the ovaries and eggs of other osseous fish."—SYRSKI.

Hohnbaum-Hornschuch presented in a dissertation published in 1842—a paper which should be rightly considered as of great importance in the literature of this question. The questions concerning the ovaries of the Eel may be regarded as having been brought to a distinct conclusion by Rathke, who, in the year 1850, published an article describing a gravid female Eel, the first and only gravid specimen which had, up to that time, come into the hands of an investigator.[1]

DISCOVERY OF THE MALE EEL BY SYRSKI.—The history of the search for the female of the Eel having been given, for the most part, in a translation of the work of Dr. Jacoby, it seems appropriate to quote the same author concerning the search for the male Eel, which, though much shorter, is none the less interesting.

In the dissertation of Hohnbaum-Hornschuch, published in 1842, the opinion was expressed that certain cells found by the author in the ovaries, which differed from the egg cells by their form and contents, should be regarded as the spermary cells of the Eel, and that the Eel should be regarded as hermaphrodite. Six years later Schlüser presented an interesting dissertation upon the sexes of Lampreys and Eels in which he pronounced these opinions of Hohnbaum-Hornschuch to be erroneous, and expressed the opinion that the male Eel must be extremely rare, or that it was different, perhaps, from the female. From this time up to the beginning of 1870, a male Eel was never seen, nor do we find any opinions expressed concerning the form of the male of the Eel or its reproductive organs.[2]

According to Robin, in 1846 George Louis Duvernoy (Cuvier, Anatomie comparée, éd. 2, 1848, tome viii, p. 117) described the ruffle-tube type of the testis of the Lampreys and Eels, with the free margin festooned in lobules, shorter to the right than to the left, like the ovaries, etc. He added: "At the breeding season we perceive in it an innumerable quantity of granulations, or small spermatic capsules, the rounded form of which has often led to their being confounded with the ovules, at least in the Eels, in which, in reality, these capsules are nearly of the same size as the ovules, but the latter are distinguished by their oval form." The ovules are spherical, and not oval; but the other facts are fundamentally correct. It is also in error that Duvernoy adds (p. 133): "The Eels and the Lampreys have no deferent canal, any more than an oviduct. Like the ova, the semen ruptures the capsules in which it has collected and diffuses itself in the abdominal cavity, whence it is expelled in the same way as in the ova."

By some droll coincidence the University of Bologna, and soon after that of Pavia, were again prominent participants in the eel tournament. At the meeting of the Bologna Academy, December 28, 1871, Prof. G. B. Ercolani read a paper upon the perfect hermaphroditism in the Eel.[3]

Fourteen days later Prof. Balsamo Crivelli and L. Maggi read a detailed and elaborate paper upon the "true organs of generation in Eels." These investigators, without concerted action, had all at once brought up the celebrated issue of the previous century; this time, however, having specially in view the male organs of the Eel. All were convinced that they had reached a final result by their investigations. The results were certainly very peculiar. In the paper of Ercolani it was claimed that the snake-like folds of fat, which had formerly been noticed near the ovarium, were nothing else than the spermaries of the Eel, and that upon the left side of the animal

[1] Jacoby. Der Fischfang in der Laguns von Comacchio. Berlin, 1880, pp. 23–30.

[2] Robin, Comptes rendus, 1881, p. 383.

[3] Jacoby states that in a paper by Rathke, published in 1838 in the *Archiv für Naturgeschichte*, he remarked: "I expect soon to be able to say something concerning the male organs of the Eel." It would be very interesting to know whether in the papers left by this skillful investigator there may not have been recorded some valuable observations concerning the male Eel.

this organ developed into a true testicle, while the one upon the right side shrank up and became functionless. In the work of Crivelli and Maggi, on the other hand, the folds of fat next to the ovary were also considered to be the male organs of the Eel, while the one on the right-hand side of the animal was considered without any doubt to be the male reproductive organ. The last-named authorities described the spermatozoa which they had seen in this stripe of fat upon the right side. Since these stripes of fat were universally found in all Eels, and always in connection with the former, the investigators could come to no other conclusion than that the Eels were complete hermaphrodites.

The male organ of the Eel, as described by Ercolani, as also by Crivelli and Maggi, shows how carefully investigations may be expended upon things which are not in the least equivocal, since there was not the slightest trace of structure like that of a spermary. The cells of this body in the lining of the stomach next to the ovary are simply fat cells, with all the characteristic peculiarities, just as they are given in all the manuals of histiology. Professor Rauber, of Leipsic, has examined these fat cells carefully, and they have also been investigated in many Eels by the writer, Dr. Jacoby. Never has anything but fat cells and blood-vessels been found in them. The so-called spermatozoa, described in the work of Maggi and Crivelli, proved to be microscopic fat particles or crystalline bodies, such as are commonly found in fat cells.[1]

In the mean time, at Trieste, the question concerning the male organs of the Eel was making a very important advance. Darwin had already expressed the opinion that among nearly all fishes the female was larger than the male. He states that Dr. Günther had assured him that there was not a single instance among fishes in which the male was naturally larger than the female. This opinion may, perhaps, have induced Dr. Syrski, director of the Museum of Natural History at Trieste, now professor in the University of Lemberg, when he undertook, at the request of the marine officials of Trieste, the determination of the spawning time of the fish which were caught in that region, and was obliged to take up the eel question, to devote his attention especially to the smaller Eels. Dr. Hermes, in behalf of Dr. Syrski, protests against this idea, stating, on the authority of the latter, that the published opinions of Günther and Darwin were unknown to him prior to the publication of Jacoby's paper. Up to that time every investigator had chosen for investigation the largest and fattest of Eels, thinking that the largest and oldest specimens must have the most highly developed organs of generation. On November 29, 1873, Syrski found in the second specimen which he investigated—an individual fifteen inches long, which is now preserved in the museum at Trieste—a completely new organ, which had never before been seen within the Eel by any former investigator, although tens of thousands of Eels had been zealously studied.[2] Syrski published his discovery in the April number of the Proceedings of the Imperial Academy of Sciences, Vienna, in 1874.[3] The most important point of the discovery was stated to be that, in all the specimens of Eels in which the Syrskian organ was found, the well-known collar-and-cuff shaped ovary, the female organ of generation, was entirely wanting. It was evident from this that Eels were not hermaphrodites. The question now arose, is the newly discovered organ

[1] In a microscopic investigation of fatty tissues it is very easy for the so-called Brownian molecular movements to be mistaken for moving spermatozoa, especially in fishes, whose spermatozoa, if not very much magnified, show only the head and appear like little bodies globular in form.

[2] "I commenced my investigations," writes Syrski, "on the 29th of November last year (1873), and already in the second Eel which I dissected on that day I found the testicles, and therefore a male individual of the Eel. I sent in March of the following year (1874) to the Academy of Sciences in Vienna a preliminary communication, which was read at the public session held the 15th April, and printed in the reports of the academy."

[3] In 1875, Professor von Siebold found male Eels in the Baltic at Wismar, although this discovery was not at that time made known to the public. They have since been found in the German Ocean, in the Atlantic, and in the Mediterranean.

in the Eel, in its external form, as well as inner structure, so different from the ovary that it could be considered as a partially developed or peculiarly shrunken ovary? According to all researches which have up to this time been made there is the highest kind of probability that this newly discovered structure is actually the long-sought male organ of generation. The investigator cannot, however, answer this question with complete certainty, since the thing which is most necessary to the solution of this question, namely, the finding and the recognition of the spermatozoa, has not yet been accomplished.

In February, 1879, Professor Packard announced the discovery of spermatozoa in Eels from Wood's Holl, Massachusetts, but soon after declared that this was a mistake, and that he had been deceived by molecular movements among the yolk nuclei in the female organs. The discovery of spermatozoa in the spermaries of the Conger Eel, recently announced by Dr. Hermes, of Berlin, is, however, sufficient to demonstrate fully the correctness of Syrski's theory. The confirmation in the case of the common Eel is solely a matter of time.

INTERNAL CHARACTERISTICS OF MALE AND FEMALE EELS.—The differences between the organs of sex in the Eel are well described by Benecke. The ovaries of the Eel are two yellowish or reddish-white elongate organs as broad as one's finger, situated alongside of the backbone, arranged in numerous transverse folds, extending through the entire length of the abdominal cavity. They have no special opening to the outside of the body, and their contents must be discharged into the abdominal cavity and must find exit through the very small opening situated behind the anus. These two bodies, on account of their great size, are of course not easily overlooked, but they contain such a great quantity of fatty cells and the eggs imbedded in them are so small and delicate that one might easily believe, even after a superficial microscopic examination, that the whole organ consists only of fat. While the eggs of other fishes measure from one to three millimeters in diameter, and sometimes are much larger, still the eggs in the ovary of the Eel have, on an average, a diameter of about one-tenth millimeter, and are so closely surrounded by fatty cells with outlines much more strongly marked that it requires great skill to prepare a microscopic slide in which they shall be as plainly visible as they are in the accompanying illustration, in which they are magnified one hundred and fifty diameters. When a person has a microscope which magnifies only one hundred diameters, it is best to put a portion of the ovary in water when dissecting it, in order that the eggs may be easily found. It is much easier to find the eggs in young Eels, seven or eight inches in length, than in adult fish, since in the former, although the ovaries and the eggs are smaller, the fat cells have not made their appearance, and the eggs are, therefore, plainly visible at the first glance through the microscope. The number of eggs is extraordinarily large, amounting to many millions. The eggs of larger size which sometimes are found in great quantities in Eels that have been cut up, and have been considered to be eel eggs, have always proved to be the eggs of other fish which they have swallowed, and in the course of cutting them up have been found in the Eel's belly.

The male Eels, which are found only in the sea and in the brackish water, are much smaller than the females, rarely exceeding fifteen or sixteen inches in length; in them, in the place of the ovaries in the female, are found spermaries, which differ in appearance in the manner shown in the illustration. These consist of two tubes which stretch the whole length of the body cavity, situated close to each other, and provided with numerous sacculations. Ripe spermatozoa are as rarely found in these organs as eggs ready to be laid have been found in the ovaries of the female. According to many accounts the male Eels, which later were found also by von Siebold in the Baltic Sea at Wismar, differ from the females in the possession of a proportionally sharper

snout, less conspicuous dorsal fins, darker coloration of the back, a more prominent and metallic luster upon the sides, the clean white coloration of the belly, and the larger size of the eyes. I propose to reproduce here the original descriptions and figures of Syrski, the discoverer of the male Eel.

Having met, writes Syrski, with many errors regarding the female organs of reproduction in the descriptions hitherto given of them, I intend to commence by describing these organs, first with the view of rectifying and completing the details, and also for the purpose of comparison with the male organs.

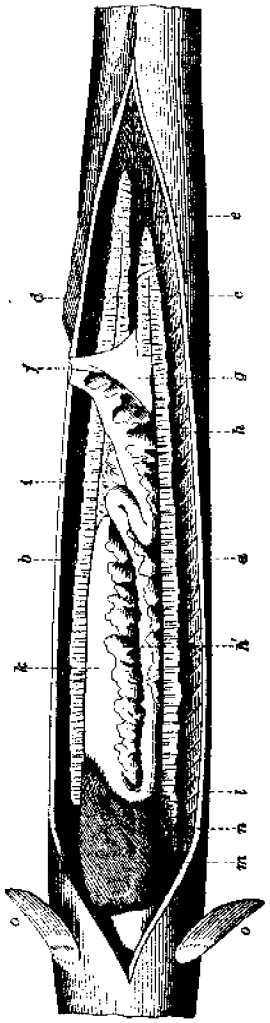

FIG. 1.—*Female Eel, longitudinal section of the abdomen; natural size.*
a. Right ovary.
b. Left ovary.
c. Accessory part of right ovary.
d. Left accessory part.
e. Dividing membrane.
f. Anal depression.
g. Urinary bladder.
h. Fat on the right side, erroneously taken for the testicles by some.
h'. Similar fat covering the stomach.
i. Fat on the left side.
k. Stomach.
l. Pylorus.
m. Liver.
n Gall-bladder.
o,o. Pectoral fins.

THE OVARIES OF THE EEL.—The organs (Fig. 1) two in number, are ribbon-shaped, with leaflets on their outer face, and with transverse folds. In the natural position of the live fish, the one extends to the left and the other to the right of the alimentary tube, following most of its angles nearly the whole length of the abdominal cavity to the place where the dorsal parietes are confluent with the lateral.

The right ovary commences at a point nearly corresponding to that where on the outside the right pectoral fin ends, and the left ovary commences about two centimeters and ends three to four centimeters behind the former. They extend three to six centimeters back of the anus, into the caudal part of the animal's body; they do not, however, unite in a single body, as some have asserted, but both are toward the end inclosed in a peritoneal membrane, and are separated from each other by the union of these membranes, having each on their inner face an accessory ovary (*pars recurrens ovarii*). In rare cases is such an accessory ovary wanting either on the right or on the left side.

The ovaries in fully grown Eels are in the middle about two centimeters larger, and posteriorly terminate in a thread-like form. They are not smooth on both sides, but have, as was said above, on their outer side numerous transverse folds (Fig. 2) full of eggs (Fig. 3).

It is another of Rathke's erroneous assertions, likewise maintained by others, that the genital opening through which the eggs pass out from the abdominal cavity is formed by two holes, a right one and a left one. I have invariably found in all specimens examined a simple hole, which communicates with the right and left half of the abdominal cavity by means of a transverse fissure between the straight intestine and the urinary bladder (*fissura recto-vesicalis*) and opens in the urethra (Fig. 4).

It is generally admitted that the eggs, when loosened from the ovaries, fall indiscriminately into the abdominal cavity, but it is not said which way they take in order to go out through the genital aperture. As I have invariably found that the fully developed ovaries lean with their outer surface against the side of the abdominal cavity, and approach with their free edges the lower portion of this side, forming, so to speak, a furrow, I must conclude that the loosened eggs

descend between the abdominal partition and the folds and leaflets of the ovary in the above-mentioned furrow, and from it pass to the genital aperture without scattering in the abdominal cavity.

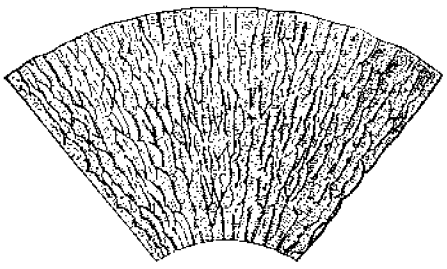

FIG. 2.—*Piece of the ovary, twice its natural size, with ovarian leaflets arranged in transverse rows, on its surface.*
The shorter border attached to the dorsal wall of the abdominal cavity; the longer being free.

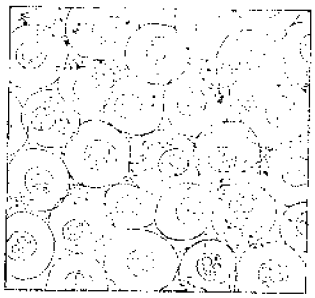

FIG. 3.—*Piece of a somewhat developed ovary, one hundred times the natural size, showing the transparent eggs with the germinative vesicle and the germinative dots.*

As to the development which the ovaries undergo, I have observed from the end of November till the beginning of March, in many adult Eels, of the length of 530 millimeters and more, that the ovaries were of the breadth of fifteen to twenty-five millimeters, and of a yellowish and sometimes reddish-white color, produced by the development of adipose tissues and of the blood-vessels and not by the eggs filled with little globules of fat; the genital aperture and the *fissura recto-vesicalis* were open.

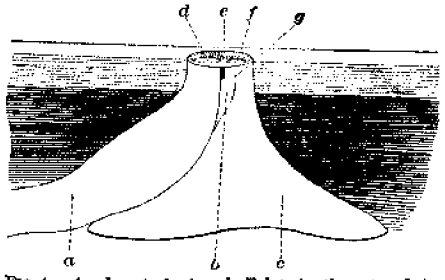

FIG. 4.—*Anal part of a female Eel, twice the natural size.*
a. Straight intestine.
b. Fissura recto-vesicalis.
c. Urinary bladder.
d. Anus.
e. Partition.
f. Urogenital opening.
g. Outlet of the genital opening in the urethra.

In other Eels, of a length sometimes of 600 millimeters and more, I found the ovaries less broad, with but little fat, and of a mucous and almost glassy appearance, so that I could discern the so-called vesicles and germinative dots (*nuclei* and *nucleoli*); the genital aperture and the *fissura recto-vesicalis* were closed.

The ovaries of young Eels, of the length of about 500 millimeters, contained invariably but little fat, and the eggs were without globules. The gradual growth and enlargement of the ovaries go on simultaneously with the opening of the genital orifice. According to the quantity of fat contained in the ovaries, they have a mucous and glassy, or more or less opaque or white, appearance, or have small shining dots. From the end of March till October I found in the majority of Eels which I examined, measuring 600 to 700 millimeters in length, that the ovaries were scarcely white, and that the genital aperture was closed. The number of eggs contained in both developed ovaries reaches, according to my calculation, five millions. The larger eggs measured by me had a diameter of one-fourth to one-fifth millimeter, while the eggs of an adult 'Grongo' (*Conger*) had, according to my measurements, a diameter of one-third of a millimeter, and those of the 'Murena' (*Muræna helena*) almost one millimeter, which explains to me why the ovaries of the two last-mentioned species of fish have long since become known.

In an Eel measuring 590 millimeters, examined on the 6th July, the left ovary was entirely wanting, and replaced by a mass of fat.

THE SPERMATIC ORGANS.—The position of these organs (Fig. 5), which are not ribbon-shaped like the ovaries, but represent two longitudinal rows, each with about fifty lobules (Fig. 6), of the width at most of three millimeters, and found only in Eels not more than 430 millimeters long, corresponds entirely with that of the ovaries. In these organs are likewise found

toward the posterior end, the spermatic organs (*partes recurrentes*), which, however, as is the case with the ovaries, are sometimes wanting.

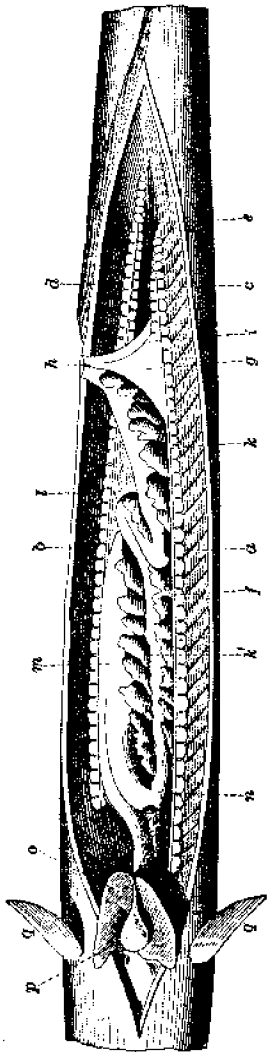

FIG. 5.—*Male Eel (natural size).*

a. Right testicle.
b. Left testicle.
c. Right accessory part.
d. Left accessory part.
e. Dividing membrane.
f. Deferent canal.
g. Seminal pouch.
h. Anal depression.
i. Urinary bladder, covered to a great extent by the seminal pouch.
k. Fat on the right side.
k'. Similar fat covering the stomach.
l. Fat on the left side.
m. Stomach.
n. Pylorus.
o. Liver, turned up to show the inner surface adhering to the œsophagus and the stomach.
p. Gall-bladder.
q, q. Pectoral fins.

The spermatic organs can be distinguished at the first glance from the ovaries of the adult Eels and those of the young Eels, not only by their lobular form, but also by their shining, glassy appearance, by the surface of the individual lobes, which is smooth and without leaflets, and by the much greater density of the tissue, so that with a pair of pincers one can take off a large portion of the organ, which could not possibly be done with a more developed ovary whose tissue is as tender as a cobweb, and is composed of small vessels formed of a thin membrane and filled with eggs and fat.

The fibrous tissue of the spermatic organs is composed of vascular compartments with thicker partitions, inclosing, according to the development of the organ, granular globules (Fig. 7).

These compartments are joined toward the inside and the base of the lobes, which are united to a tube (*vas deferens*), which, cæcal at the commencement, runs along the entire length of the abdominal cavity, and opens near the straight intestine (*rectum*) in a triangular pouch, which likewise contains a *vas deferens* starting from the caudal part of the spermatic organ. This pouch has its outlet in the general orifice, which opens in the urethra (Fig. 8).

As regards the development of the spermatic organs, I have observed that the lobes of these organs in young Eels, measuring not more than 200 to 300 millimeters in length, are not yet very distinct, forming two thin ribbons differing but little from ovaries of the female in their average size. In Eels measuring about 400 millimetersin length, the testicles can easily be distinguished from the ovaries. The former, much straighter, and with tissue, as has been already remarked, much more solid, are provided with a much more developed net-work of vessels; their lobes are very distinct and the deferent canals are usually open, while the ovaries present the appearance of two continuous ribbons, have a more delicate tissue, and an almost mucous appearance, and contain the eggs with the germinative vesicles.

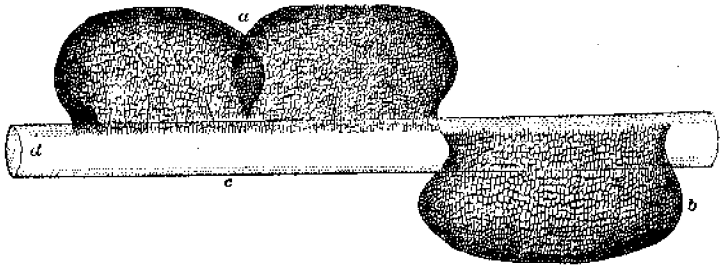

FIG. 6.—*Three lobes of the right testicle, with the deferent canal (enlarged ten times).*

a. Lobes, seen from their outer surface.
b. Lobe, seen from its inner surface.
c. Deferent canal.
d. Anterior part of the same.

The deferent canals and the genital orifice are closed in young Eels of the male sex, and open simultaneously with the development of the lobes.

In the male Eels examined by me from March to October I have found individuals, of 400 millimeters and more in length, whose genital orifice and deferent canals were invariably open, while in some of the smaller ones they were closed and in others open.

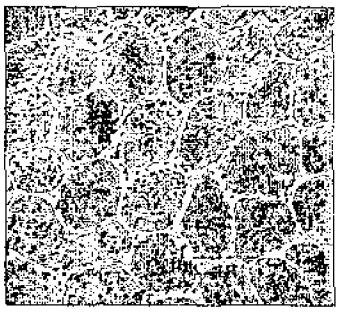

FIG. 7.—*Piece of the testicle (one hundred and sixty times enlarged), showing the vascular tissue and the small granules.*

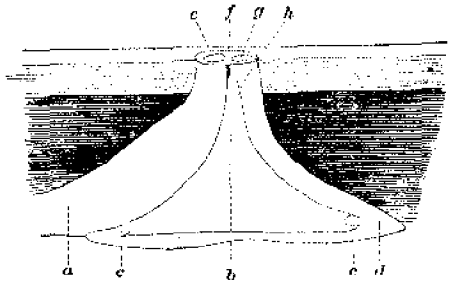

FIG. 8.—Anal part of the male Eel, enlarged twice.
a. Straight intestine.
b. Fissura recto-vesicalis, covered by the outside wall of the seminal pouch
c. c. Outlet of the anterior and posterior part of the deferent canal in the pouch.
d. Urinary bladder.

Of the 258 Eels examined by me, the males and females were in about even proportion; the greatest length of the former was about 430 millimeters, while the latter were of all sizes up to 1,050 millimeters, which shows that the males are smaller than the females.

EXTERNAL CHARACTERISTICS.—The external differences presented by living Eels (remarks Jacoby), corresponding to the presence of an ovary and the supposed male organ, are very interesting.

The most important, writes Jacoby, is (1) the difference in the size and length of the animal. Syrski states that the largest Eels found by him with the supposed male organ measured about 17 inches (430^{mm}). I have, however, found specimens with this organ at Trieste and in Comacchio which measured 17 to 19 inches (450 millimeters to 480 millimeters). All the Eels which exceeded this size, for instance those which were over three feet in length (one millimeter) many of them growing to the thickness of the arm of a strong man, have been hitherto found to be females. The other recognizable external characters in the female are (2) a much broader tip of the snout in comparison with the small, either attenuated or short and sharply pointed, snout of the Eel with the supposed male organ; also, (3) a clearer coloration in the female, usually of a greenish hue on the back, and yellowish or yellow upon the belly, while the others have a deep darkish-green, or often a very deep black upon the back and always a more perceptible metallic luster upon the sides (I, once in a while, found Eels covered all over with a brownish tint, always possessing the organ of Syrski), usually exhibiting also a white color upon the belly. In addition (4) there is an important external character in the height of the dorsal fin; all females have these fins much higher and broader than the Eels of the same size which possess the supposed male organ. Finally, (5) there is a character, which is not always a safe one, in the greater diameter of the eye in the Eels with the supposed male organ. Eels with quite small eyes are almost always found to be females; Eels with the organ of Syrski usually have comparatively large eyes, yet female Eels with quite large eyes are not unusual.

The following proportional measurements, the average results of the study of a great number of Eels measured by me, will be of general interest. Column *a* gives the total length of the Eel; *b* the breadth of the snout between the nostrils; *c* the breadth of the snout between the eyes; *d* the length of the snout from the center of the eye to its tip; *e* the average measurement of the

eyes; *f* the length of the head to the gill-opening; *g* the height of the dorsal fins, all the measurements being given in millimeters.

	A. Eels with supposed male organ.							B. Female eels.							
	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	
I	480	6	13.5	15	8	52	5	480	8.5	12	17	5	62	9	I
II	470	6	10.5	12	7	54	6	475	7.5	14.5	16	8	59	8.5	II
III	445	5	11	12	6	47	6	440	8	12	14	5	56	7.5	III
IV	411	4	9	12	5.5	47	6	410	8	12.5	13	7.5	51	7	IV
V	386	4.5	9	12	5.5	46	4	378	7.5	11	12	5	49	7.5	V
VI	370	3.5	7	10.5	5	40	6	369	7.5	11	13	6.5	51.5	7	VI
VII	344	4	7.5	10	4.5	40	5	342	6	8	11	4.5	44	6.5	VII
VIII	319	4	7	10	5	40	4.5	313	5.5	8	10.5	3.5	41	6	VIII

According to the distinguishing marks which have been given, special reference having been paid to the height and narrowness of the dorsal fin, much success has been met with in picking out, in the fish-market of Trieste, the Eels which possessed the organ of Syrski; absolute certainty in recognizing them cannot, however, be guaranteed. If one is searching among living Eels with no characters in mind with the exception of the first—that of length—he will find in every ten Eels, on an average, eight females, and two with the supposed male organ; but, if the selection is made with a careful reference to all these marks of difference, the proportion changes, and out of every ten examples about eight will be found with the supposed male organ.[1]

For another excellent discussion with figures of the characters of male and female Eels, the reader is referred to a translation of an article by S. Th. Cattie, in the Proceedings of the United States National Museum, vol. iii, pp. 280–284.

EELS SUPPOSED TO BE VIVIPAROUS.—The discovery of the two sexes has not, however, writes Benecke, settled the question whether the Eel lays eggs or brings its young alive into the world. There has always been a strong disposition to adopt the latter hypothesis, and there are many people at the present day who claim to have been present at the birth of young Eels, or to have found a quantity of young Eels in adult Eels which have been cut open. Frequently ichthyologists hear accounts of occurrences of this kind, and receive specimens of supposed little Eels, from one to two inches in length, which have been kept alive for several days in a glass of water. These are usually thread-worms, *Ascaris labiata*, which live by the hundred in the intestinal cavity of the Eel, and which may be easily distinguished from the Eels of the same size by the sharp ends of the body, the absence of fins, of eyes and mouth, and by the sluggishness of their motions. The smallest Eels, less than an inch in length, have already the complete form of the adult, and are also transparent, so that with a magnifying glass one may perceive the pulsations of the heart, and see behind it the brownish-red liver; the mouth, the pectoral, dorsal, anal, and caudal fins, are easily seen, and the black eyes cannot be overlooked. In addition to the intestinal worms, the young of a fish of another family, *Zoarces viviparus*, have given opportunity to the ignorant for many discoveries; for instance, Dr. Eberhard, in No. 4 of the "Gartenlaube" for 1874, described and illustrated an "embryo of the Eel," which, in company with about a thousand similar embryos, had been cut out of the belly of an Eel. This tolerably good drawing at first sight is seen to represent the embryo of *Zoarces*, which is almost ready for birth, since it still possesses a very minute umbilical sac. It is very evident that the minute egg of the Eel could hardly produce a great embryo with an umbilical sac which exceeds by more than a hundred times in size the whole egg. It is also evident that the imagination of the writer had exaggerated the two or three hundred young in the *Zoarces* to a thousand.

[1] JACOBY: Der Fischfang in der Lagune von Comacchio.

SEARCH FOR YOUNG EELS.—As might have been foreseen, remarks Jacoby, Syrski's discovery drew attention anew to the solution of the eel problem. In the spring and summer of 1877 the German and Austrian papers and journals were full of articles and paragraphs upon this subject. Among others the following announcement made the rounds of the press: "Hitherto, in spite of all efforts, science has not succeeded in discovering the secret of the reproduction of the Eel. The German Fischerei-Verein in Berlin offers a premium of fifty marks to the person who shall first find a gravid Eel which shall be sufficiently developed to enable Professor Virchow in Berlin to dissipate the doubts concerning the propagation of the Eel." Herr Dallmer, of Schleswig, inspector of fisheries in that province, offered to transmit communications to Berlin, and in 1878, in the January number of the "German Fishery Gazette," he published a detailed and very interesting report of his proceedings. He wrote, among other things, that it was quite beyond his expectation that this announcement would have found its way into nearly all the German journals between the Rhine and the Weichsel and from the Alps to the sea. The number of letters which he received first rejoiced him, then surprised him, finally terrified him, so that at last he was obliged to refuse to attend to the communications. He had learned at Berlin that an equal number of communications from all parts of Germany had been received, sent directly to the address of Professor Virchow. Objects which were said to be young Eels cut out of the parents, but which were really thread-worms, were sent to him by dozens; the most incredible stories, usually from women, about great thick eggs which they had found in Eels, were received by him. A witty Berliner communicated to him in a packet sent by express the information that the eel problem was now happily solved, since a lady Eel in Berlin had given birth to twins. Finally Herr Dallmer found himself compelled to insert the following notice in the "Schleswiger Nachrichten": "Since the German Fischerei-Verein has offered a premium for the first gravid Eel, the desire to obtain the prize, curiosity, or the desire for knowledge has created so lively an interest upon this point that it might almost be called a revolution. I at one time offered, when necessary, to serve as an agent for communications, but since business has compelled me to be absent from home a great part of the time, I would urgently request that hereafter packages should be sent direct to Professor Virchow in Berlin. I feel myself obliged to inform the public upon certain special points. The premium is offered for a gravid Eel, not for the contents of such an Eel, since if only these were sent it would be uncertain whether they were actually taken from an Eel. The Eel must always be sent alone; the majority of senders have hitherto sent me only the intestines or the supposed young of the Eel, which were generally intestinal worms; the Eel itself they have eaten; nevertheless the prize of fifty marks has been expected by nearly all senders," etc. By this transfer of the responsibilities the inspector of fisheries has rendered a very unthankful service to Professor Virchow; he was obliged to publish a notice in the papers in which he urgently stated that he wished to be excused from receiving any more packages, for he would hardly know what to do with them. The comic papers of Berlin now circulated the suggestion that hereafter the Eel should be sent to the investigators only in a smoked state. This amusing episode is interesting in showing how remarkable an interest the whole world was beginning to take in the eel problem.[1]

NORMAL REPRODUCTIVE HABITS.—"It may be assumed with the greatest safety," writes Benecke, "that the Eel lays its eggs like most other fish, and that, like the Lamprey, it only spawns once and then dies. All the eggs of a female Eel show the same degree of maturity, while in the fish which spawn every year, besides the large eggs which are ready to be deposited at the next spawning period, there exist very many of much smaller size, which are destined to mature here-

[1] Zoologischer Anzeiger, No. 26, p. 193; American Naturalist, xiii, p. 125; and Jacoby, p. 44.

after, and to be deposited in other years. It is very hard to understand how young Eels could find room in the body of their mother if they were retained until they had gained any considerable size. The eel embryo can live and grow for a very long time supported by the little yolk, but when this is gone it can only obtain food outside of the body of its mother. The following circumstances lead us to believe that the spawning of the Eel takes place only in the sea: (1) that the male Eel is found only in the sea or brackish water, while female Eels yearly undertake a pilgrimage from the inland waters to the sea, a circumstance which has been known since the time of Aristotle, and upon the knowledge of which the principal capture of Eels by the use of fixed apparatus is dependent; (2) that the young Eels with the greatest regularity ascend from the sea into the rivers and lakes.

All statements in opposition to this theory are untenable, since the young Eels never find their way into land-locked ponds in the course of their wanderings, while Eels planted in such isolated bodies of water thrive and grow rapidly but never increase in numbers. Another still more convincing argument is the fact that in lakes which formerly contained many Eels, but which by the erection of impassable weirs have been cut off from the sea, the supply of Eels has diminished, and after a time only scattering individuals, old and of great size, are taken in them. An instance of this sort occurred in Lake Müskendorf, in West Prussia. If an instance of the reproduction of the Eel in fresh water could be found, such occurrences as these would be quite inexplicable.

In the upper stretches of long rivers the migration of the Eels begins in April or May; in their lower stretches and shorter streams later in the season. In all running waters the eel fishery depends upon the downward migrations. The Eels press up the streams with occasional halts, remaining here and there for short periods, but always make their way above. They appear to make the most progress during dark nights when the water is troubled and stormy, for at this time they are captured in the greatest numbers. It is probable that after the Eels have once returned to the sea, and there deposited their spawn, they never can return into fresh water, but remain there to die. A great migration of grown Eels in spring or summer has never been reported, and it appears certain that all the female Eels which have once found their way to the sea are lost to the fisherman. In No. 8 of the German "Fischerei Zeitung" for 1878, Dr. Schock published certain statements sent to him by Dr. Jacoby. It is remarked in this paper, among other things, that after the deposition of the spawn the female Eel dies a physiological death, and that occasionally the sea in the neighborhood of the mouths of rivers has been found covered with dead Eels whose ovaries were empty. When, where, and by whom this observation was made, and who pronounced upon the empty ovaries in these dead fish, is unfortunately not mentioned.

A great number of the Eels remain in inland waters while others proceed to the sea, either because their eggs are at this time not sufficiently ripe, or perhaps because they are sterile. It would seem probable that the increase in the size of the eggs in the wandering Eels begins to be very rapid after August and September, while in the earlier months of the year, in all Eels of moderate size, the eggs were at the utmost but about 0.09 millimeters in diameter. In September of the same year, I found (as an average of numerous measurements) a diameter of 0.10; in October, 0.16; in November, 0.18 to 0.23, while the eggs showed other characters connected with approaching maturity which earlier in the season were not to be seen. All the Eels which were captured later—in December and in January—part of which came from rivers and harbors, part from the harbor of Putzig (Putziger Wiek), had eggs measuring from 0.09 to 0.16 millimeters, although among the fish examined were some which measured three feet in length.

DO MALE EELS LEAVE THE SEA AND ENTER FRESH WATER?—This problem is one of great interest, both to the biologist and the fish-culturist; it is, in fact, the one disputed point still remaining to be solved. Upon its solution appears to depend the final decision of the question, still so warmly debated both in Europe and America, "Do Eels breed in fresh water only, in salt water only, or in both fresh and salt water?" As has already been stated, the theory for a long time generally accepted is that the Eels are "catadromous," descending to the sea to spawn. This theory is, however, sharply contested by many observers, chief among whom on this side of the Atlantic is Hon. Robert B. Roosevelt, president of the American Fish Cultural Association. It appears probable to the writer that the truth lies somewhere between these two extremes, and that it will be hereafter ascertained that the Eel, like a majority of other animals, has flexible habits, sometimes deviating from its ordinary custom, which appears to be to spawn in salt or brackish water.

Male Eels have been found in the following localities:

(1) In 1874, by Syrski, in the fish markets of Trieste, these markets being supplied with Eels from Chioggia on the Adriatic, and to a lesser extent from the lagoons of Comacchio.

(2) In 1875, on the coasts of France, by Dareste.

(3) In 1875, among specimens of *Anguilla marmorata* from India.

(4) In 1875, in the Baltic, at Wismar on the Danish coast, by Professor von Siebold.

(5) In 1877, in the lagoons of Comacchio, by Jacoby. Among twelve hundred specimens, five per cent. were males; while among those less than fifteen inches in length twenty per cent. were males. This was in brackish water.

(6) In 1879, at Trieste, by Dr. Hermes, who found fifteen males among twenty Eels selected by Dr. Syrski.

(7) In 1880, on the Baltic coasts of Denmark, by Dr. Hermes. Out of one lot of thirty-six from Wismar, he obtained eight males, thus repeating von Siebold's observation.

(8) In 1880, from the Baltic between Zealand and Saland, Denmark. Out of one lot of thirty-six, Dr. Hermes obtained eight males.

(9) In 1880, in France, by Robin.

(10) In 1880, by Cattie.

(11) In 1880, by Dr. Hermes, at Cumlosen, on the Elbe, about one hundred and twenty miles from the German Ocean.

(12) In 1880, at Rügers on the Baltic, by Dr. Hermes, who found forty-four and one-half per cent. males in one lot of 137.

(13) By Dr. Pauly, among Eels planted at Hüningen, in Alsace-Lorraine.

It has been shown by Dr. Pauly that among the very young Eels [*Montée*] taken near the mouths of rivers is a considerable percentage of males, which, when transplanted to fresh water, will there retain their masculine characters and develop into perfect adult males. This discovery is, of course, of the utmost importance to fish-culturists making the attempt to introduce Eels into new waters. Its importance has already been pointed out by Director Haack.

The practical lesson to be learned is simply this, that young Eels, for introduction into strange waters, must be taken from very near the mouths of rivers, in order that both males and females may be secured. The interest to zoologists lies in the fact that Pauly's discovery renders the theory of von Siebold less plausible, indicating that the sexes of the young Eels are differentiated before they begin to mount the rivers and that the males do not ascend beyond the limits of brackish water.

Dr. Pauly's discovery is so interesting that I propose to translate his own account of it. The investigation was made, I believe, in Munich, and the report from which I quote was published in the "Austro-Hungarian Fishery Gazette," of Vienna, December 23, 1880. Dr. Pauly writes:

"During the past year I have received from Court-fisherman Kuffer a large number of Eels, which I have used in my investigations. The large individuals, all of which came from the lakes of Northern Italy, were females. I received, however, from the same individual, another lot of Eels, consisting of much smaller individuals, weighing from twenty to ninety grams (two-thirds of an ounce to three ounces), also taken in fresh water. At the request of Professor von Siebold, I had paid particular attention to the sexes of the Eels which I was engaged in investigating, and to my great astonishment I found that a large majority of these small Eels (nineteen out of twenty-seven) were males, possessing, instead of the familiar ovaries, the 'Lappenorgan' described by Dr. Syrski. A histological examination of these organs convinced me that the structure of these tissues agreed with that described by Freud. . . .

"My next inquiry was very naturally concerning the locality whence these Eels had been obtained. I learned that Kuffer had received them two years before from Director Haack at Hüningen, and, upon questioning Director Haack, learned that they had been brought from a French river, the Sèvre nantaise, where they were caught as young fry [*montée*] at a distance of ten or twelve miles from its mouth, and furthermore were at the time of examination about four years old. The small size of these fish, their age being taken into consideration, satisfied me that they had been reared in captivity, since uncultivated Eels would have been much heavier. The females in this lot of Eels exceeded the males in length and weight, and also exhibited those external characters described by Jacoby as indicating sex.

"The locality in the Sèvre niortaise where these fish were taken may easily, especially at flood tide, have been within the limits of brackish water; my observations do not prove, therefore, that male Eels enter fresh water.

"Dr. Jacoby found male Eels in the lagoons of Comacchio, where the water is brackish. These males must have ascended in the 'mounting' as fry, and probably at the approach of sexual maturity descend with the females to the sea. My investigations and those of Jacoby prove only this: that the young female Eels do not necessarily break away from their parents and from their birthplaces at sea, and entirely alone proceed upon their migrations, while the males scatter through the sea, but that their brothers seem to accompany them part of the way upon their journey. But how far? Do the males know where pure fresh water begins, and are the fry of different sexes found mingled together only at the river mouths? If we bear in mind the fact that the male organs had so long escaped discovery, that, on account of their crystal-like transparency, their detection in a fresh Eel is so difficult, etc., may we not admit that past conclusions are probably erroneous, and that although thousands of fresh-water Eels have been studied by different investigators, male Eels may yet be found in our streams, especially when more of the smaller individuals have been examined?"

Dr. Pauly then discusses the observations of Dr. Hermes, who found eleven per cent. of males among Eels taken at Wittenberge, on the Elbe, about one hundred and twenty miles from the German Ocean, and no males whatever at Havelberg, twenty or thirty miles higher up the stream, and closes his essay with the following conclusions: "*Male Eels undoubtedly ascend the rivers, but the numerical percentage of males to females appears to diminish as one proceeds up the streams.*" This fact is opposed to the theory proposed by some one that young Eels are at first of undifferentiated sex, and have the tendency under the influence of fresh water to become females, under that of salt water to develop male characters.

BENECKE ON THE MOVEMENTS OF YOUNG EELS.—Benecke gives the following thorough discussion of the movements of young Eels:

The young Eels, hatched out of the eggs at sea, doubtless live at the bottom until they grow, through consumption of rich food substances there to be found, to a size from one to three centimeters. When they have attained this size they begin their wanderings in immense schools, proceeding to ascend into the rivers and lakes. These wanderings of the young Eels have been known for a very long time; for instance, in the lagoons of Comacchio, in which they may be found, for the most part, after they have gained the length of from six to eight millimeters, and in France, later also in England, Denmark, Sweden, and, more recently, in Germany they have also been observed.

According to the French reports young Eels are hatched out early in the winter, and in February, having attained the length of four or five centimeters, they appear in the brackish water at the mouth of the Loire in immense numbers, soon to begin their wanderings up the stream. They swim in crowded schools at the surface of the river right up to the banks, and little detachments of the army deploy at the mouth of each tributary and pursue their wanderings along its course. These swarms of young Eels are called in France "Montée," in Italy, "Montata." The number of the young fish is, as might be expected from the number of the eggs in the ovary of the Eel, wonderfully large. Redi has recounted that, from the end of January to the end of April the young fish continue wandering up the Arno, and that in 1867 over three million pounds of them were taken in five hours. Into the lagoons of the Comacchio the Eels pour from February to April. In March and April they have been noticed in many French rivers, in which the migration continues for from eight to fourteen days. The first account of these wanderings in Germany was that given by von Ehlers. In 1863 he wrote to von Siebold: "This took place about ten years ago, in the village of Drennhausen, in the province of Wesen, in the Kingdom of Hanover. As we were walking, towards the end of June or the beginning of July, on a dike, which at that place projects out into the Elbe, we noticed that along the entire shore there might be seen a moving band of a dark color. Since everything which takes place in the Elbe is of interest to the inhabitants of that region, this phenomenon immediately attracted attention, and it soon became apparent that this dark band was composed of an innumerable body of young Eels, which were pressing against each other, as, at the surface of the stream, they were forcing their way upwards towards its source, while they kept themselves so close to the shore that they followed all its bendings and curves. The width of this band of fish at the place where it was observed (where the Elbe has a considerable depth) was perhaps a foot, but how deep it was could not be observed, so thickly crowded together were the young Eels. As they swam a great number could be taken in a bucket, and it was very annoying to the people who lived along the Elbe that, so long as the procession of fish lasted, no water could be taken out of the river which was not full of the little fish. The length of the young Eels was, on an average, from three to four inches; the thickness of the body was about equal to that of a goose-quill. By themselves might here and there be seen swimming Eels of greater size, but none of them were probably more than eight inches in length. All of them, even the smallest, were dark colored. This wonderful procession of fishes continued unbroken and of the same density throughout the whole of the day on which it was first observed, and continued also upon the following day. On the morning of the third day, however, not one of the young Eels was to be seen."

Similar observations have been made at Wittenberge, on the Elbe. Kuffer observed great quantities of young Eels, of about three centimeters in length, in the brackish water of the Eider at Friedrichsstadt; so also did von Stemann.

"Every year," writes the latter, "from April to the end of June, there appear great masses of young Eels, which are present in large schools towards the Upper Eider, seeking in every way to pass each other. In April the first Eels show themselves generally singly; cold weather has evidently kept them back up to this time; since this year, until to-day, no ascent whatever has taken place, and now the approach of the great schools is beginning. Where the current is feeble the procession is broad; but where the Eels encounter a strong current—near a mill—it becomes small, and presses close to the shore, in order to overcome the currents. The little animals swim eagerly and rapidly along near the banks until they find a place over which they decide to climb. Here they lie in great heaps, and appear to await the rising of the tide, which makes their ascent easier. The tide having risen, the whole mass begins to separate without delay; Eel after Eel climbs up on the steep wall of rock, determined to reach the little pools, at the height of fifteen or twenty inches, into which some of the water from the Upper Eider has found its way. Into these holes the little animals creep, and have yet to travel a distance of forty or fifty feet under the roadway before they can reach the Upper Eider. Another detachment betakes itself to the sluiceways, and clings to the cracks in the wood; also around the mills their ascent may be observed, especially about sunrise."[1]

Davy sends a similar account from Ireland. He was a witness of the ascent of young Eels, or "Elvas," at Ballyshannon, at the end of July, 1823; he speaks of the mouth of the river under the fall being "blackened by millions of little Eels about as long as a finger, which were constantly urging their way up the moist rock beside the fall." "Thousands," he adds, "died; but their bodies, remaining, served as a ladder by which the rest could make their way; and I saw some ascending even perpendicular stones, making their way through wet moss or adhering to some Eels that had died in the attempt."[2]

Such is the energy of these little animals that they continued to find their way in immense numbers to Loch Erne.

In the little Eels which ascend the rivers there are no traces of sexual organs, but in the fresh water they develop only into females. One of the most recent observations made by Dr. Pauly, in Munich, would appear to contradict this idea, since he discovered male Eels among the fish which were brought with a lot of young Eels to Hüningen, were kept there for two years in ponds, and were finally released in the fish pond of Court-fisherman Kuffer. We should bear in mind, however, that these young Eels were captured at the mouths of fresh rivers in brackish water; and that among the numerous small Eels which swim in the brackish water there must be many larger specimens, in which the male organs have already begun to develop. Such are doubtless those which were sent in the male condition to Hüningen and Munich, and were there recognized as males. This presumption can be set aside only if male Eels shall hereafter be found among the fish which are caught in the upper part of rivers in the condition of young fry.

Concerning another important fact which is connected with the movements of the young fry of the Eel, I became acquainted last year (in the course of an exploration of the waters of the district of

[1] Professor Benecke had in his possession some of the young Eels, which escaped from all the vessels in which they were confined, and even climbed to the ceiling of his room.

[2] EEL-FAIRS IN CONNECTICUT.—Fresh-water Eels may be caught in large numbers, in weirs along the lake streams, when descending at the fall equinox to deposit their spawn in some lower region, and in the following August their offspring, from three to six inches long, return in immense numbers. The basin of the Still River Falls, near Colebrook line, is for several days alive with them. They may be seen laboriously crawling up every rock which is moistened by the spray of the fall, and endeavoring to reach their ancestral lake or dam. At the foot of the Niagara Falls this phenomenon may be witnessed on a large scale at the same season of the year or later, and probably in other places where the fall is too high and the current too swift for the young Eels to stem it without contact with the rocks.—BOYD: Annals of Winchester, Connecticut, p. 26.

Konitzkunde) with the river Brahe, at Mühlhof, above Rittel, where a high dam was built in 1846 and 1847 for the purpose of watering a large system of meadows by the overflowing of the stream. Below the dam is an inclined plane (constructed of boards), about three hundred feet long, built for the purpose of preventing the water, which rushes out when the sluice-gate is opened, from washing away the bottom of the stream and its banks. This plank floor consists of two layers, the lower one of two-inch, the upper one of three-inch boards. The grade of the dam at Mühlhof (thirty-three feet three inches) has entirely cut off the ascent of the fry of the Eel into the upper part of the Brahe and the lakes tributary to it, and the number of Eels caught above the dam—which was formerly very considerable—has become reduced almost to nothing. In the year 1847 the construction of the dam and the inclined plane was completed. In 1852 the upper layer of the planks on the plane had warped and sprung up in many places, so that it had to be torn up for repairs. The cause of the warping was immediately discovered; thousands of Eels, as thick as a man's finger, somewhat flattened in shape, and, on account of the absence of light, of a pure white color, filled the space between the two layers of planks, and their united pressure from beneath had caused the upper layer to yield; these Eels had found their way between the boards as fry, where they had found sufficient food and had grown to such a size that the pressure of their united strength had pushed up the roof of their prison. These facts, observed by an old millwright, were communicated to me by Privy Councillor Schmid, of Marienwerder, who supervised the construction of the Mühlhof dam, and he fully confirmed them.

Eels of four inches in length, which in May are plenty in fish ponds, by the end of October reach a length of ten inches and the thickness of a man's little finger; in the following fall they measure from twenty to twenty-four inches, and in the third year are ready to be eaten. On account of their rapid growth and hardy nature, in consequence of which latter they live in mudholes and unprofitable waters of all kinds, the breeding of Eels is a very remunerative business. The young fish (of which, at the time of their first appearance at the mouths of rivers, it takes 1,500 to 1,700 to make a pound, while, when taken later and a little farther from the sea, it takes only 350 to 400 for the same weight) may be obtained at low prices from France through Hüningen, or in Germany from Randesberg, and, through the Berlin Aquarium, from Wittenberge, and, when the temperature of the air is not too high, may be carried in soft moss throughout all Germany.

According to the statement of the well-known Paris fish-merchant, Millet, two pounds of Eels, planted in a muddy pond in 1840, in five years yielded 5,000 pounds of fine Eels.

JACOBY'S TOUR TO COMACCHIO IN 1877, AND HIS CONCLUSIONS.—"In the fall of 1877," writes Jacoby, "I undertook a journey from Trieste, by way of Ravenna, to Comacchio. Convinced of the difficulty of the questions to be solved by my own previous labors, I had not great hopes of finding sexually mature Eels, either gravid females or mature males. My highest aim was at the beginning to determine the following points: (1) Whether evidences of preparation for breeding might not be found in the Eels which were wandering in the fall toward the sea; (2) to what extent Eels with the organ of Syrski could be found participating in this migration; (3) as far as possible to obtain Eels from the sea at a distance from the coast in order to compare their organs of reproduction with those of the Eels in the lagoons.

"In determining the answers to the first two questions I was able to make some new and interesting discoveries, but with regard to the latter, my most diligent efforts were absolutely fruitless.

"I found that the Eels when migrating to the sea in the fall took no food. In many hundreds examined by me, caught during their movement, I found stomach and intestines entirely empty; that the Eels during their migrations eat nothing is also known to all fishermen and watermen of Comacchio. At the same time, the Eels which remained in the lagoons were more or less filled

with food, not only those which were not sufficiently mature to migrate, but also a breed of Eels which never goes to the sea, but remains throughout its entire life in the lagoons.

"There may be found in Comacchio, and doubtless everywhere where Eels live in great numbers in brackish water along the coast, a peculiar group of Eels which, as far as I could determine, consists entirely of sterile females. These female Eels with ovaries present a very peculiar phenomenon; when they are opened one finds, instead of the well-known yellowish-white, very fatty, cuff-shaped organ, a thin, scummy, slightly folded membrane, not at all fatty, often as transparent as glass, and of about the same proportional size as the so-called cuff-shaped organ. When this membrane is examined under the microscope there may be seen in it eggs very transparent in appearance, with yolk-dots absent or with yolk-dots very small and few. This organ appears to be an abnormally developed ovary incapable of fertilization. These sterile females, which I found of all sizes, even up to the length of twenty-seven inches, present all of the acknowledged female characters in great prominence and in an exaggerated degree: the snout is broader, and often, especially at the tip of the under jaw, extraordinarily broad; the dorsal fins are, on the average, higher; the eyes are much smaller, especially in large specimens, and the coloring is clearer; the back of a clearer green and the belly yellower than in the normal female. The flesh of these sterile females has a very delicate flavor, and quite different from that of other Eels. I was quite astonished at the fine flavor when I tasted them for the first time in Comacchio. The flesh, as the expression goes, melts upon the tongue. It is even possible to distinguish them while living, by feeling them with the hand, their soft bodies being very different from the hard, solid, muscular flesh of the others.

"In Comacchio these Eels are called 'Pasciuti.' Coste called them 'Priscetti,' and defined them to be those Eels which had not become ripe, but which were at least a pound in weight. The name 'Priscetti' is, however, very incorrect, as I have become convinced by questioning the fish inspectors and by hearing the conversations of the fishermen. 'Pasciuto' means 'pastured,' and the fishermen understand by this, those Eels which do not migrate, but which remain through the whole year feeding in the lagoons. They include, however, under this name, Eels of two kinds—the sterile females already described, and the Eels which are not yet ripe, as well as the normal females and supposed males whose period of migration is somewhat remote. This circumstance is a cause of much difficulty to the investigator.[1]

"The studies on the second point to be solved were of special interest, viz, the determina-

[1] It has been noticed by many early writers that there are certain Eels which never come to the sea—Risso, in his "Histoire Naturelle," tome 3, p. 198, and S. Nilsson, in his "Scandinavisk Fauna," tome 4, p. 663. The latter called this variety "Grasaal," or Grass-Eel, and spoke of its yellowish-green coloration and the soft, delicious flesh. Strange enough, both these writers spoke of the sharper snout of this Eel, and Risso, who founded upon it another species, *Anguilla acutirostris*, described it as blackish above and silvery below. These descriptions apply in every particular to the non-migratory Eel of Comacchio. Jacoby remarks that all the sterile females brought to him under the name "Pasciuti" were distinguished by their broad snouts. The following tables were prepared at Comacchio. *a* gives the total length of the body of the Eel; *b*, the breadth of the snout between the nasal tubes, in millimeters.

A.—Sterile females or Pasciuti.			B.—Normal females.			C.—Eels with supposed male organs.		
	a.	*b.*		*a.*	*b.*		*a.*	*b.*
I	508	10	I	511	8	I	—	—
II	480	8.5	II	497	7	II	480	6
III	458	11	III	465	9	III	470	6
IV	443	9	IV	447	7	IV	445	5
V	426	8.5	V	425	6	V	428	5
VI	409	8	VI	407	6	VI	403	5
VII	395	11	VII	396	7	VII	393	5.5

tion of the presence at Comacchio, and the behavior of Eels with organs of Syrski. I can answer this question very briefly, since among twelve hundred specimens examined by me at the fishing stations and at the so-called eel factories (with the exception of the largest specimens, which are always females) I found an average of five per cent. with the organ of Syrski; of the Eels under fifteen inches in length (forty-five centimeters) on an average there were twenty per cent., so that the conclusions as to their abundance were very similar to those at Trieste, where the fish market is supplied, for the greater part, with Eels from Chioggia, and to a less extent with those from Comacchio.

"In Comacchio the largest Eels with the organ of Syrski, which I have observed, were about seventeen inches (forty-eight centimeters) in length, the smallest about nine inches (twenty-four centimeters). All of these were found among the Eels taken during their migration to the sea, and, like the females, were found with stomachs completely empty or slightly filled with a slimy substance. It was impossible to find in any specimen a more advanced development of the Syrskian organ than in those examined in summer at Trieste.

"With reference to the third question undertaken by me, which relates to the actual kernel of the eel question, that is, the possibility of obtaining the Eels which have migrated out to sea, in order to obtain in this manner the sexually mature milters and spawners, I have been unable to obtain any results. I have, so far as my opportunities permitted, left no stone unturned to gain its solution. I went out to sea from Magnavacca and from Codigoro, on Chioggian vessels, and many times have fished myself, and have stimulated the fishermen by offers of reward to endeavor to obtain Eels at sea, but I am forced to the conclusion that with the ordinary means this cannot be done.

"Intelligent, gray-headed fishermen of Chioggia, who by means of their fishing apparatus know this part of the Adriatic as well as they know their own pockets, have assured me that throughout their entire lives they have never caught a grown-up river Eel in the sea at any distance from the coast. The Eels which were brought to me at Mannbach as having been caught in the sea, and which I found to be the ordinary females, or Eels with the Syrskian organ, were either from localities close to the shore where they are not rare, or were taken in the Palotta Canal. There was no lack of attempts at deception. Fishermen took Eels from the shore with them in order to be able, on their return, to claim that they had been caught at sea. In the immediate neighborhood of the coast they are, as it has been stated, in the spring-time not rare, and there are not the slightest differences between these and the Eels of the lagoons. I found both females and Eels with the organ of Syrski with their reproductive organs in the same immature condition as in Comacchio; evidently they had just come through the Palotta Canal from the lagoon into the sea. A certain distance, perhaps one or two marine miles from the coast, every trace is lost of the adult Eels which wander by the many thousand into the sea. Strange as this problem appears at first sight, it is easily understood when the character of the fishing apparatus is considered: the nets are those used in the capture of lobsters, and are thrown over the bottom; they have meshes much too large to hold the Eels, or, when they are small-meshed, they do not touch the bottom. The problem can only be solved by using apparatus constructed especially for the purpose."[1]

Jacoby proposes the following questions, which, in his opinion, cover the still unanswered points concerning the natural history of the Eel, and answers them in accordance with the results of his own observations:

[1] JACOBY: Der Fischfang in der Lagune von Comacchio, pp. 45–53.

Question 1. How can the fact be accounted for that no one has ever found mature females and males, spawners and milters, among the Eels?

Answer. The Eels require the influence of sea-water for the development of their reproductive organs. As is now definitely understood, they leave the rivers and the brackish lakes on account of the undeveloped condition of their reproductive organs, for the purpose of becoming sexually mature at sea. That these migrations to the sea take place for the purpose of reproduction appears to be certainly proved by the fact that the young Eels leave the sea in the spring, and that the migrating Eels, like other fishes at the spawning season, abstain from eating.

Q. 2. When and where occurs the necessary development of the reproductive organs of the Eel to a condition in which they are capable of fertilization?

A. Development of the reproductive organs takes place in the sea, not close to the shore, but at a distance and in deep waters. This development is extraordinarily rapid, when the immature state in which the migrating Eels are found is taken into consideration; they must become sexually mature within a few, probably five or six, weeks of the time that they enter the sea. At Comacchio the emigration takes place between the beginning of October and the end of December.

Q. 3. Where does the act of spawning take place, the fertilization, and the deposition of the eggs?

A. There are probably certain definite spawning places in the sea, off the mouths of the rivers. These are the mud-banks to which the Eels go, for the purpose of spawning, in great numbers. The young fish are developed upon these mud-banks, and from eight to ten weeks after their birth, at the beginning of spring, find their way to the mouths of rivers, which they ascend.

Q. 4. What becomes of the grown-up Eels after spawning time, and why do they remain lost to sight and never again come back into the rivers?

A. The old Eels, male and female, without doubt, die soon after the spawning season. The very unusual rapid development of their reproductive organs has such an effect upon the systems of the adult Eels that they die soon after the act of reproduction. That is the reason why they are never seen to wander back again.[1]

An intelligent Chioggian, the owner of a fishing vessel, in answer to my question as to where the old Eels staid, answered, "They die on the mud-banks after they have propagated their young."

This hypothesis may be confirmed in a scientific manner by the analogous circumstances in the history of the Lamprey. Panizza, in his description of the sea Lamprey, *Petromyzon marina*, remarks that both the males and females of this species after the spawning period are brought up dead. Concerning the river Lamprey, *P. fluviatilis*, Statius Müller remarks that when they spawn they slowly fall away and die. Concerning the little Lamprey, *P. planeri*, August Müller, the discoverer of its larval form, has recorded the same opinion.[2]

192. THE CONGER EEL—CONGER, OR LEPTOCEPHALUS CONGER.

The Conger Eel is occasionally seen in the summer on the coast of the New England and middle States, and is known to our fishermen as the "Sea Eel." No observations have been made of its habits by American zoologists.

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[1] As a confirmation of this view, von Siebold was the first to make this hypothesis.

[2] Op. cit., pp. 53–56.

The observations of Dr. Otto Hermes, director of the Berlin Aquarium, who has recently discovered the true nature of the organ of Syrski in the Conger, are extremely interesting:

"Since Syrski, in 1874, found the organs in *Anguilla vulgaris*—which are called by his name, and which, by him and most zoologists, were taken for the male reproductive organs—it is only

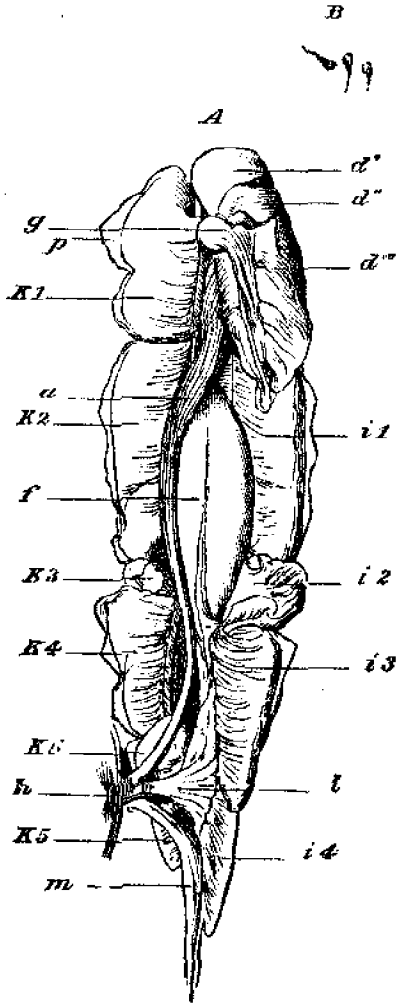

FIG. 9.—*A. Ripe male reproductive organs of a Conger Eel thirty inches in length, ½ natural size.*

a. Intestinal canal.
d', upper, *d''*, middle, *d'''*, lower portion of the liver, which has been thrown to one side.
f. Air-bladder.
g. Gall-bladder.
h. Anal aperture.
i_1, i_2, i_3, i_4. Folds of the left spermary.
k_1, k_2, k_3, k_4, k_5. Folds of the right spermary.
l. Seminal pouch.
m. Urinary bladder.
p. Skinny covering of the spermary.
R. Spermatozoa.

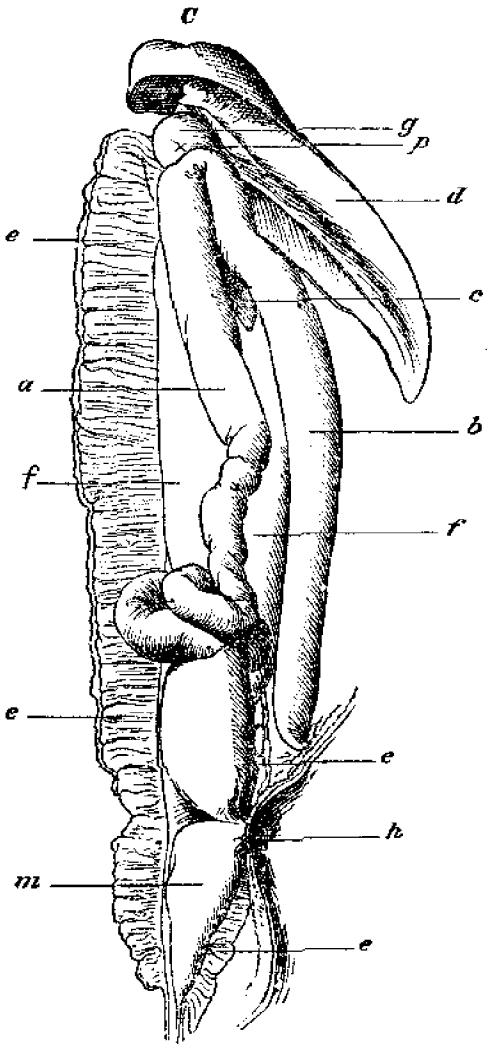

FIG. 10.—*C. Undeveloped reproductive organ of a female Conger Eel thirty-four inches long, ½ natural size.*

a. Stomach.
b. Cæcal appendage.
c. Spleen.
d. Liver.
e. Right ovary.
e'. Left ovary.
f. Air-bladder.
g. Gall-bladder.
h. Anal aperture.
m. Urinary bladder.
p. End of left ovary.

necessary that a ripe male Eel should be found in order to settle forever the question of the sexes of the Eel. Up to this time all efforts have failed to reach the desired result. The histiological investigations of the Syrskian organs pursued by S. Freud render it more probable that these were young roes; yet there remained all the time a doubt, since the spermatozoa had not been actually

observed, and this uncertainty is an insuperable obstacle to the acceptance of the Syrskian discovery. The supposed discovery of spermatozoa by A. S. Packard in the male Eel proved to be another delusion. The contradiction of this imaginary discovery appeared in No. 26 of the second volume of the Zoologischer Anzeiger, p. 193, in which it was stated that the motile bodies were not spermatozoa, but yolk particles. This correction was also made by von Siebold's assistant, Dr. Pauly,[1] and by S. Th. Cattie.

"The reproductive organs of *Conger vulgaris* are very similar to those of *Anguilla vulgaris;* in the undeveloped condition they show the ovaries lying in the same position in a cuff-shaped band of a proportionally large size. Since *C. vulgaris* reaches nearly twice the size of *A. vulgaris*, individuals of six feet in length are not rare. The ovary is developed in captivity, and this, I am convinced, is often the cause of the death of the Eel. In a Conger which died in the Berlin Aquarium, and was cut open, the ovaries protruded very extensively, and a specimen which lies in the Frankfort Aquarium burst on account of the extraordinary development of the ovaries. The ovaries of this Eel, which weighed twenty-two and one-half pounds, themselves weighed eight pounds, and the number of eggs was about 3,300,000. The want of a natural opening for the escape of the eggs was evidently in this case the cause of death. Male specimens of the Conger in an undeveloped condition I have hitherto never had the opportunity to investigate. I received, however, in the fall of 1879 a number of sea Eels, taken in the vicinity of Havre, whose average length was from twenty-four to twenty-seven inches. These Eels ate greedily and grew rapidly. Only one was tardy in its development, so that it could be easily distinguished from the rest. This, which was the smallest of the Congers in the aquarium, died on the 20th of June, 1880, and was examined by me on the same day. I was very much delighted when I found the sexual organs very different from those which I had ever noticed before. After a single cut into them, there flowed out a milky fluid, which, under the microscope, with a power of 450 diameters, showed a great number of spermatozoa, in the liveliest motion, and in which head and tail were evidently visible. There could be no doubt that I had found a sexually mature male of *Conger vulgaris*. Two fragments of the roe were laid aside for further investigation, and the Eel, which was twenty-eight inches long, was prepared first in alcohol and then in Wickersheimer fluid."

In the paper before us Dr. Jacoby presents a full anatomical description of the generative organs of the Conger as demonstrated by himself and Dr. Rabl-Rückhard. It seems unnecessary to repeat this description, since the organs are very similar to those in the common Eel. By the kindness of Dr. Hermes we are permitted to reproduce the drawings which accompany this description.

Compared with the description of the roe, and the figure of the organ found by Syrski and by Hermes, called "Lappenorgan," a great similarity is noticed between them. It must be borne in mind that in this case we were comparing the entirely undeveloped organs of the Eel with the fully ripe reproductive organs of the Conger, so every doubt as to the male nature of the Syrskian organs ought to be thrown aside. Also in the comparison of the size of the male with that of the female the Conger shows the same relations as the Eel investigated by Syrski, to wit, that the males are smaller than the females.

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[1] Austrian Fishery Gazette, 1880, No. 12, p. 90.

V.—STURGEONS, SKATES, SHARKS, AND LAMPREYS.

193. THE BOWFINS—AMIIDÆ.

THE BOWFIN OR JOHNNY GRINDLE—AMIA CALVA.

The one species belonging to the single genus in this family is peculiar to the fresh waters of the United States. It occurs in the Great Lakes, where it is called "Dogfish" and "Sawyer"; in the streams of Western Vermont, where it is the "Mud-fish"(?), as also in the streams of the Southern Atlantic coast from the Neuse southward. It is also abundant in the smaller rivers flowing into the Gulf of Mexico and in all parts of the Mississippi Valley, where it is variously called the "Johnny Grindle," "Bowfin," and "Dogfish." The Bowfin is an object of great interest to naturalists on account of its affinities with the great fossil group of ganoid fishes. It is exceedingly tenacious of life, like its allies, the garfishes. It attains the length of two feet and the weight of twelve pounds. Though not considered eatable in the North, it is very highly esteemed by the negroes of the South, who say "there is nothing sweeter than a Mud-fish." It is often taken by sportsmen on a trolling spoon, and is considered "gamy."

The Bowfin is probably more interesting on account of its voracity, and the wholesale destruction with which it pursues other fishes, than by reason of its own intrinsic worth. The young are thought to be excellent bait for pickerel and pike. The best description of the habits of this fish is here quoted from the pen of Charles Hallock:

"They take frogs, minnows, and sometimes the spoon. Their habitat is deep water, where they drive everything before them. They are very voracious and savage. Their teeth are so sharp and their jaws so strong that they have been known to bite a two-pound fish clean in two the very first snap. They are as tenacious of life as the eel. The young, when about six inches long, make a famous bait for pickerel and pike. To use it, run the hook into the mouth right up through the center of the head, through the brain, cast a hundred times, catch several fish, and at the end of three to six hours he will kick like a mule. Put one hundred in a rain-barrel and you can keep them all summer without change of water. For the aquarium the young have no equal, and on account of the spot in the tail are quite attractive; but nothing else but snails can live in the tank. He will kill a lizard or any other living thing the instant it touches the water.

"Dr. Estes says: 'I have sent these young Dogfish hundreds of miles for the aquarium. It is only necessary to keep them in water, a change scarcely being required. The adults are the great 'Jumpers' of the lake. On certain days they are to be seen in all directions jumping clean out of the water, and turning complete somersaults before again striking. They spawn in May and June among the grass and weeds of the sloughs, if they can reach them in time. As soon as the spring rise comes, usually in May and June, and connects the inland sloughs with the lake (Pepin), they run up and over into the sloughs, deposit their eggs, and remain near the beds and young just as long as they can and not be shut in by the receding water. The eggs hatch in eight and ten days, the parents remaining with the brood two or three weeks, if possible, but will leave them much sooner if necessary to save themselves. The young will not make any effort to escape to the lake until the next season, when, if an opening occurs, they come pouring out in countless numbers. At this time we take them by stretching the minnow seine across the opening and raising it when full. They are now from three to six inches long, fat and chubby. I come now to mention a

peculiar habit of this fish, no account of which I have ever seen. It is this: While the parent still remains with the young, if the family become suddenly alarmed, the capacious mouth of the old fish will open, and in rushes the entire host of little ones; the ugly maw is at once closed, and off she rushes to a place of security, when again the little captives are set at liberty. If others are conversant with the above facts, I shall be very glad, if not, shall feel chagrined for not making them known long ago.'"[1]

194. THE PADDLE-FISHES—POLYODONTIDÆ.

The "Paddle-fish" or "Duck-billed Cat," *Polyodon spathula*, is one of the most characteristic fishes of the rivers of the Western and Southern States. It reaches a length of four to six feet, and a weight of thirty pounds or more. It feeds on minute organisms present in mud. The long snout or spatula is used to stir up the mud on which, and the animals within it, the fish feeds. The fish is rarely or never used as food. Jordan states that it abounds in the lower parts of the Ohio River, where it is often taken in nets.

195. THE STURGEONS—ACIPENSERIDÆ.

The Sturgeons of the Atlantic Coast.

Two species of Sturgeon are supposed to exist on our Atlantic coast. The most abundant of these, *Acipenser oxyrhynchus*, is now generally supposed to be identical with the common Sturgeon of Europe, *A. sturio*. The other, *A. brevirostris*, which is distinguished from *A. oxyrhynchus* by its shorter and blunter nose, has not yet been found north of Cape Cod, and appears to be comparatively less abundant, although both species are found in great numbers in the larger rivers and estuaries during the summer season, and are frequently seen leaping from the water, especially at dusk. A leaping Sturgeon is a striking object, the whole length of the fish appearing above the surface before it falls back with a splash into the water.

The Sturgeon attains a length of five to twelve feet. In Europe, individuals of the common Sturgeon eighteen feet long have been secured. The spawning season is in spring and early summer. Their eggs have several times been artificially impregnated by the fish-culturists attached to the Fish Commissions of the United States and of New York. They spawn in the lower stretches of the rivers, and perhaps also at their mouths, in brackish water.

Sturgeon are classed by fishermen among the fishes which "live by suction." The mouth is situated upon the under surface of the head, and is not provided with teeth, but is surrounded with a cup-shaped organ composed of powerful muscular tissue, by means of which it grubs for its food in the mud. Its stomach resembles that of the menhaden and mullet, though comparatively more muscular, since, like the gizzard of a fowl, one of its uses is to triturate the food which has been swallowed, and which consists largely of mollusks and crustaceans. Around the mouth is a group of large and sensitive tentacles, which aid the fish in its search for food.

No one has yet made a careful study of the habits of the Sturgeon in our waters, and in fact European zoologists have made little progress in the study of their own species.

Within the past few years the capture of the Sturgeon for smoking and for the manufacture of caviare from its eggs has attained considerable importance on the Atlantic coast.

The capture and economic uses, and the statistics of the products of the sturgeon fishery, will be fully discussed by Col. M. McDonald in a subsequent portion of this work.

[1] Sportsman's Gazetteer, 1877, pp. 324–326.

THE LAKE STURGEON—ACIPENSER RUBICUNDUS.

The most satisfactory investigation of the Lake Sturgeon is that published by Milner in Part II of the Report of the United States Fish Commission, pages 67 to 75. This species inhabits the Great Lakes and the waters lying to the northward, and the rivers of the Mississippi Valley. It is especially abundant in the Upper Lakes. It is a smaller species than the Atlantic Sturgeon, and has a greater number of plates or scutes upon the sides—according to Jordan, about thirty-four instead of twenty-eight.

SPAWNING HABITS.—Milner records the following observations upon the general habits and history of the Lake Sturgeon:

"The spawning season of the Sturgeon in the more southern lakes occurs in the month of June; in Lake Superior it is a little later. Early in June, in the southern end of Lake Michigan, they begin to congregate near the shores and at the mouths of the rivers, the Kalamazoo River, emptying at Saugatuck, Michigan, being a favorite spawning ground. They may be seen in the evening in this river leaping from the surface, throwing their bulky forms entirely out of the water. At Pier Cove, Michigan, on the 11th of June, 1871, schools of Sturgeons were at the edge of the shore in a few feet of water, and men from the vicinity were in the habit of wading out and drawing them ashore with gaff-hooks. Eighteen were taken in this way the morning we visited the locality. They were said to be found in the vicinity every year about this season, remaining about a fortnight. It is likely they were spawning at the time. Whether the shore of the Lakes, where the waves would disturb the eggs in every storm, is a natural spawning ground is a question. They may have been late arrivals seeking the mouth of the Kalamazoo River, a few miles to the north of which they are said to ascend to the first dam, many miles inland.

"Mr. J. G. Portman, of Benton Harbor, successful as a fish-culturist, has seen the Sturgeon at this season lying in numbers on a shallow clay ledge at the edge of a stream, several of them lying flat on their backs, with their bellies upward, rolling and splashing in shallow water with apparent enjoyment. Two or three that were taken with spears were opened and the stomachs examined and found to contain some of the sturgeon spawn. At the mouth of Calumet River, South Chicago, Illinois, July 1 of the year just referred to, a large lift of Sturgeon were brought ashore, looking flaccid and emaciated, and but one specimen out of over twenty individuals contained spawn. In the vicinity of Bayfield, Wisconsin, on Lake Superior, they were seen late in the month of July with the ovaries full of spawn, and the milt of the male fishes large, making it probable that the time of spawning was later in colder water than in warm.

"SIZE.—The Sturgeon of this species attains the largest size of any fish of the Lakes. They are taken only within comparatively shoal waters and in some of the bays, and among the islands they are very abundant. The largest specimen it has been my fortune to see did not quite attain the length of six feet, though there are traditions in localities on the Lakes of nine-foot Sturgeons; the average of the mature ones taken is less than five feet.

"Their food consists almost entirely of the shell-fish of the Lakes, principally gasteropods, the thinner-shelled kinds of the genera *Physa*, *Planorbis*, and *Valvata* being found broken in the stomachs, while *Limnæa* and *Melantho* remain whole. A few eggs of fishes have been found at different times, but examination of stomachs during the spawning season of some of the most numerous fishes did not prove them to be very extensive spawn-eaters.

"ENEMIES.—In Green Bay the fishermen set their pounds for fall fishing about the 10th of September. The Sturgeon are in abundance, and the nets often contain a hundred or more. This is said to continue until about the middle of October, when they diminish in number and the white-

fish become plentiful. As the latter are the fish sought for, the Sturgeon are considered a nuisance and annoyance. A few fishermen are considerate enough to lower the corner of a net and allow them to escape, but the commoner way is to draw them out of the net with a gaff-hook and let them go wounded, or to take them ashore and throw them on the refuse heap, asserting that there will be so many less to trouble them in the future. A very large number are destroyed in this way, probably equaling or exceeding the number taken in the vicinity of Sandusky.

"The spawn is probably subjected to the depredations of numerous fishes. It is not likely that the young Sturgeon, except in the earliest stages of their growth, suffer from the attacks of other fishes, as they are too well defended with the sharp spine of their shields to make a comfortable mouthful for any fish of the Lakes, and after the spine disappears have attained a size large enough to render them safe.

"A parasite that troubles the Sturgeon is the Lamprey Eel, *Petromyzon argenteus*, Kirt., which is found very frequently attached to the skin. The circular scars and raw sores sometimes found upon the Sturgeon and attributed to this cause by the fishermen are correctly accounted for in this way. It is probable that their natural food is the slime or mucus exuded in abundance from the pores, but they frequently retain their hold upon a spot until they have eaten through to the flesh, and deep ulcerous cavities occasionally result from the sore.

"The decrease in numbers is apparent to a certain extent in localities where the pound-net has been in use for a number of years. At Sandusky, Ohio, the number brought in from the nets and handled at the curing establishment in a season are said to have nearly reached eighteen thousand a few years ago, while in 1872 the books showed a record of thirteen thousand eight hundred and eighty received. This fact has several times been advanced as an argument in favor of the pound-nets, that the destruction of the Sturgeon, asserted to be an extensive spawn-eater, more than compensated for the numbers of white-fish taken.

"As an article of food they are not generally popular. But few people in the cities know the modes of cooking that make their meat a palatable dish. A certain quantity is disposed of fresh by the peddlers. With the Canadian-French people of the Lake shore they are in demand, and are prepared in the form of soups (*bouillon*). With a good, hearty, outdoor appetite this is very palatable food, but too rich in the flavor of the oil of the fish for ordinary use. The flavor of the Sturgeon meat has very little of the taste of fish, and the bouillon, when carefully prepared by skimming off the oil, is very much like chicken-soup. A very good pickled meat is made of it by boiling it and preserving it in vinegar.

"But the best form of preparing Sturgeon is by smoking it. The smoking of Sturgeon meat has been done at different points of the Lakes on a small scale, but is only carried on to a large extent by Schacht Brothers, of Sandusky, Ohio. The method employed by this firm is the following: The Sturgeons are skinned and the viscera taken away. The thick parts are then cut into strips, and after a slight pickling in brine are smoked over a close fire. The thin portions and offal are boiled down for oil, the spawn is made into caviare, and from the bladders isinglass is manufactured.

"The smoked Sturgeon is a most palatable meat, and is quite popular, making an excellent substitute for smoked halibut, and, in the opinion of a great many, having some qualities superior.

"The caviare is made by pressing the ova through sieves, leaving the membranes of the ovaries remaining in the sieve and the eggs falling through into a tub. This is continued until the eggs are entirely free from particles of membrane, when they are put into salt pickle and allowed to remain for some time."

OBSERVATIONS BY LUDWIG KUMLIEN ON THE STURGEON OF THE GREAT LAKES.—Mr. Kumlien, while engaged in collecting the statistics of the Great Lakes fisheries in 1880, made a number of very important notes upon the abundance of the Sturgeon and upon the sturgeon fishery in that region, which will be quoted in a subsequent portion of this work.

THE STURGEONS OF CALIFORNIA.

"The common Sturgeon of the Pacific coast, called distinctively the 'White Sturgeon,'" writes Jordan, "is *Acipenser transmontanus*. It reaches a length of eight or ten feet or more, and is said to attain a weight of four to five hundred pounds. We have seen none of over one hundred and fifty pounds' weight. It is found in the Sacramento, Columbia, and Frazer Rivers in abundance, ascending them at the time of the salmon run in the spring for the purpose of spawning. Whether it enters the small streams, how long the run continues, and how far the Sturgeon ascend, are matters at present unknown. The Sturgeon feeds on crustacea, carrion, etc. In Frazer River they gorge themselves on the eulachon.

"The Sturgeon is one of the most important fish in the San Francisco market, being always abundant and very cheap. Elsewhere the abundance and superiority of the salmon cause it to be little used. Many are smoked. Caviare is made from the eggs.

"*Acipenser medirostris* is known as the 'Green Sturgeon.' Its size and distribution are the same as that of the White Sturgeon. It is, however, much less abundant. It is not used as food, being reputed poisonous. We are unable to say on what facts this evil reputation is based."

THE SHOVEL-NOSED STURGEON: WHITE STURGEON—SCAPHIRHYNCHOPS PLATYRHYNCHUS.

This species is found in abundance in all the larger rivers of the West and South. It spawns early in May, ascending smaller streams for that purpose. Jordan states that in the Ohio River it is taken in seines in considerable numbers and is used for food, though it does not seem to be highly valued. He surmises that its habits are very similar to those of the Lake Sturgeon.

196. THE CHIMÆRA FAMILY—CHIMÆRIDÆ.

RAT-FISH OF CALIFORNIA—CHIMÆRA COLLIEI.

"This fish," writes Jordan, "is known as the 'Rat-fish' or 'Rat-tail.' It reaches a length of nearly two feet, and a weight of six to eight pounds. It is very abundant everywhere from Monterey Bay northward along the coast, especially in deep bays. It feeds on fishes and takes the hook very readily. It spawns in July. The egg cases are two or three inches long, lanceolate, long and slender, without tentacles.

"The liver of the Chimæra is very large and well filled with an oil said to be superior to ordinary shark oil. The flesh is worthless and the fish is too small to be an object of pursuit. It has, therefore, no economic value."

THE BLUE CHIMÆRA—CHIMÆRA AFFINIS.

A species of Chimæra is frequently taken by the New England fishermen on the off-shore fishing banks. It was described by Professor Gill under the name *C. plumbea*, but proves to be a species previously discovered on the coast of Spain. It has no economic importance.

197. THE GAR-PIKES—LEPIDOSTEIDÆ.

THE LONG-NOSED GAR-PIKE—LEPIDOSTEUS OSSEUS.

This fish is known as "Gar-pike," "Bill-fish," "Sword-fish," etc., the names "Gar" and "Gar-pike" usually predominating. It is found in the Great Lakes, and throughout the Mississippi

Valley, as well as in all the streams of the South from Mexico to New Jersey. In all the larger streams it is abundant, sometimes extremely so, but in the smaller rivers it is scarce. It is a hardy and voracious fish, being usually considered very destructive to the young of other and better fishes. It is fair to say that remains of fishes are rarely found in its stomach. It reaches a length of five to six feet. It is usually considered wholly worthless, being killed and thrown away whenever taken. The flesh is very tough, and is said to be noxious. I have never known it to be eaten. It spawns in early summer, running up smaller streams, often in company with the various Sturgeons. At Ogdensburg, New York, they come upon the shoals for this purpose about May 20. Another spawning ground is on a beach near Point Salubrious, Chaumont Bay, New York, about a mile from the post-office.

The Short-nosed Gar-pike (*Lepidosteus platystomus*) occurs in the same waters, reaches about the same size, and is similar in habits. It is most common southwestward.

Le Sr. de Champlain, visiting the lake which bears his name in the year 1609, speaks of a large fish, undoubtedly the Gar-pike, there found:

"Among the rest there is one called by the Indians of the country *Chaousaron*, of divers lengths. The largest, I was informed by the people, are of eight to ten feet. I saw one of five, as thick as a thigh, with a head as big as two fists, with jaws two feet and a half long, and a double set of very sharp and dangerous teeth. The form of the body resembles that of the pike, and it is armed with scales that the thrust of a poniard cannot pierce, and it is of a silver-gray color. The point of the snout is like that of a hog. This fish makes war on all others in the lakes and rivers, and possesses, as these people assure me, a wonderful instinct; which is, that if it wants to catch any birds it goes among the rushes or reeds bordering the lake in many places, keeping the beak out of the water without budging, so that when the birds perch on the beak, imagining it the limb of a tree, it is so subtle that closing the jaws, which it keeps half open, it draws the birds under water by the feet. The Indians gave me a head of it, which they prize highly, saying that when they have a headache they let blood with the teeth of this fish at the seat of pain, which immediately goes away."[1]

The Alligator Gar—Lepidosteus spatula.

This species is known almost universally as the "Alligator Gar"; in Spanish, "Manuari." It abounds in large bodies of water tributary to the Gulf of Mexico, being found in Mexico and Cuba as well as in the United States. Its northern range extends to the Ohio River, where, however, it is not common. It reaches an enormous size, being sometimes more than ten feet in length. In habits it is probably essentially similar to the smaller Gar-pikes. It has no value as food, but is said to be somewhat dangerous to men and domestic animals.[2]

It is found in various tributaries of the Gulf of Mexico, and also in the headwaters of Saint John's River, Florida. It is distinguished by its broad snout. In Arkansas the country people

[1] Doc. Hist. of N. Y., iii, 1850, 6. See also, Sagard: Grand Voyage du Pays des Huron, Paris, 1632.

[2] A Man's Fight with a Fish.—Mr. James F. Simmons, of Redbone district, had a narrow and peculiar escape the other day. He was fishing on Flint River, and had attempted to swim across to get a bateau from the opposite side. About half way over the stream he stopped on a root or tree to rest. After remaining there a short time, he plunged off for the other shore. Just as he made a plunge a tremendous fish, known as the Gar, struck him, catching his thigh in its mouth, and leaving an ugly and painful wound. A regular battle then took place between the man and the fish, and lasted for some minutes, until finally Mr. S. got back on his resting place, and his enemy departed. During the fight Mr. S. threw the fish some feet above the water, but it continued the attack. Mr. S. was thoroughly frightened and called lustily for help. He has several ugly and painful wounds given him by the fish, yet none serious. This is the first time we ever heard of a Gar attacking a man, yet they say it frequently does so.—*Talbotton (Ga.) Standard*, July, 1879.

manufacture from it a kind of oil, which is used as a liniment to prevent the attacks of the buffalo-gnat. Mr. Stearns writes:

"The Alligator Gar is very abundant everywhere on the Gulf coast, living in both fresh and salt water. Like the salt-water catfish, it will eat anything. It preys largely upon all fish smaller than itself, and the young are, I believe, particularly destructive to fishes' eggs and young fry. Some think that this fish does more damage to the small food-fishes than any other fish on the coast does. It is simply useless to place 'set-nets' where the Gar is abundant. Many are caught in seines with other fishes and are thrown ashore to be destroyed. I have seen Gars that would measure seven feet in length; the average is two feet. With the larger ones the bill is not proportionately as long as with the smaller ones, but is stouter."

198. THE RAYS, TORPEDOES AND SKATES—RAIÆ.

There are six or seven species of Rays upon the Atlantic coast, none of which are of importance to man, except so far as they are dangerous or annoying to the fishermen, or are destructive of useful marine animals.

The Sting Rays.

The Sting Ray, *Trygon centrura*, ranges farther to the north than any of the other species, having been observed on the shoal parts of George's Banks; it does not, however, pass the limit of Cape Cod. The Sting Ray attains an enormous size, its disk sometimes measuring five or six feet across, and its entire length, including the long, flexible tail, ten feet or more. It feeds entirely upon the large species of marine invertebrates, such as crabs, squids, clams, and sea-snails. The strong serrated spine situated upon the top of the tail near its junction with the body can inflict dangerous wounds, and several instances are on record of serious injury to fishermen who have had their hands or feet transfixed by it. These fish are often taken in considerable numbers in the pounds and weirs.

There are two or three other species of Sting Ray or Stingaree on the southern Atlantic and Gulf coasts, the commonest of which, *Trygon sabina*, is found in the rivers, ascending the Saint John's to the upper lakes, and also clear along the coast. Concerning its habits in the Gulf of Mexico, Mr. Stearns writes:

"The Sting Ray or Stingaree is abundant all along the Gulf coast. It is present all the year, but is most commonly seen is warm weather, while upon the shoals in search of food. I have caught these fish with young continuously from April to the latter part of October. The usual number of a brood is three or four, but I have seen as many as eight or nine taken from large individuals. Possibly the age or size of the parent may affect the number of young they bear. They feed upon shell-fish. Small ones are quite tame, coming near the shore in search of food, and when disturbed quickly bury themselves in the sand or dart away a short distance. The larger and older ones are more wary, seldom coming into very shoal water, and at the least disturbance swim away with great rapidity to deep water. The Sting Ray has a barbed spine on its tail which it uses in self-defense. It is sometimes caught with hook and line, but more often in seines, and then it uses its tail as a whip upon its captors, trying to wound them with its spine. Such wounds are often dangerous, and very painful and difficult to heal. The Sting Ray attains an enormous size, and specimens six or seven feet across the back are frequently caught. I caught a specimen off Cedar Keys whose spine had been broken off and replaced by a new one which grew out beneath the old one.

"Capt. Joseph Fogarty, of Manatee, reports having seen a large school of Sting Rays in Long Boat Inlet. They were swimming near the bottom, very closely crowded together.

"The Sting Ray and Whip Ray are very often eaten on the Gulf coast, and are sold daily in the New Orleans market."

The Butterfly Ray.

The Butterfly Ray, *Pteroplatea maclura*, although a member of the same family with the Sting Ray, differs very much in its external appearance, and would hardly be supposed by the unlearned to be a fish at all. The tail is exceedingly small, while the pectoral flaps are enormously developed. The body often attains the weight of ten or twelve pounds, while its length is not more than three or four feet. The enormous extent of the pectoral flaps, resembling wings, have given origin to the common name. In an individual of the above-mentioned size the tail would not be more than three or four inches long. This species is taken in summer in the pounds, and, when Skates become more popular as an article of food, will doubtless, on account of its great size, be of economic importance. Little or nothing is known of its habits.

The Eagle Rays.

Of the Eagle Ray family, *Myliobatidæ*, of which there are three species, all except the Bishop Ray straggle north to Southern New England in summer, but only one seems to be found in Florida and the Gulf; this is the "Whipparee" or "Corn-Cracker" of the South (*Rhinoptera quadriloba*). Its habits are thus described by Mr. Silas Stearns:

"The Whipparee is common on the Florida coast. It is present in the bays the year round. In warm weather it lives on sand bars in shoal water, and in cold weather retires to deeper water. It feeds upon molluscous animals, chiefly the razor-shell fish, which is one of the commonest kinds. The Whip Ray is viviparous and brings forth its young in spring and summer, the breeding season apparently extending over five or six months. I have not found a Whip Ray containing more than three young ones, usually only two. When the young fish leave the parent they are quite active and undoubtedly able to care for themselves. The adults have stout dorsal spines, which they use as weapons of defense. These spines are barbed and slimy, and wounds from them are very troublesome and sometimes dangerous. The Whip Ray is sometimes six or seven feet across the back. During the last of July, 1880, I saw large schools of young Whip Rays, probably about half-grown, swimming at the surface at sea off Saint Andrew's Bay, and also at a point twenty miles up that bay."

The "Eagle Ray," or "Sharp-nosed Ray," *Mylobatis Fremenvillei*, does not attain a large size and is comparatively unusual in occurrence. Its food, as observed in Southern Massachusetts, is closely similar to that of the common Sting Ray.

The Bishop Ray, *Stoasodon narinari*, the "Obispo" of Cuba, is found in the West Indies and at the Bermudas; stragglers have been observed at Norfolk, Virginia.

The Devil-fishes.

The Devil-fish, *Manta birostris*, has been observed as far north as Cape May, and is said to be often see on the Gulf coast of Florida, as it swims on the surface of the water. This species attains an enormous size; individuals have been caught measuring thirty feet or more from tip to tip of the flaps. It is especially abundant on the coast of South Carolina, where its pursuit is a favorite amusement among the planters, or rather was in former years. Every one is familiar with the thrilling accounts given of this amusement by Elliott in his "Carolina Sports by Land and Water." There are instances on record of small vessels having been carried out to sea by these fish which have become entangled in the anchor ropes. The appearance of these fish at the surface, especially at the breeding season, has given origin, doubtless, to some of the stories of sea-serpents current on the Southern coast.

The Skates.

Of the Skates, *Raiidæ*, there are five species on our Atlantic coast, a list of which, with their common and scientific names and a statement of their geographical distribution, will be found on the check-list in the appendix. They are all troublesome to the fisherman, clogging his lines and pound-nets; but none of them are of the slightest economical value except the so-called "Barn-door Skate," *Raia lævis*, which is occasionally salted for use by the fishermen of Portsmouth, New Hampshire, and which has, within the last two or three years, attracted some notice in New York. Miss Corson, in her cooking school, has called attention to its excellent qualities as a food-fish, and Skates may be found on the bill of fare at certain restaurants, such as Mouquin's, on Fulton street. Only the "wings," or the fleshy flaps to the pectoral fins, are used.

The Torpedo—Torpedo occidentalis.

The Torpedo is found north as far as Cape Ann, a specimen having been taken at Lanesville in the summer of 1878. It is more or less abundant along the Southern New England and middle States coast.

The Torpedo is occasionally thrown upon the shore, and its capture in the pound-nets is not unusual. It is of no economic importance, but is of great interest to physiologists on account of its powerful electric apparatus. The fishermen know its peculiarities, and carefully avoid handling it, since a shock from a living individual is sufficient to knock a man down. It is usually called the "Cramp-fish," and, in pursuance of the old idea of the influence of signatures in medicines, the oil made from the liver is prized by fishermen as a specific for rheumatism and cramp. Captain Atwood writes:

"I have seen considerable many. They run ashore, and they have been harpooned from the shore. I have seen five hundred, I think. I used to go and look for them for their livers, for the oil. The oil is one of the best lamp oils that I ever saw. It has been used sometimes beneficially in cases of cramp. I got a gallon of oil from one liver. I don't know but I have seen a Cramp-fish big enough to make three gallons of oil."

The Rays and Skates of the Pacific coast.

Of the numerous Rays on the Pacific coast only two or three are of economic value, being brought into the market of San Francisco, when their pectoral fins are sold to the French and Italians. These are of little importance, as they are so cheap that there is no profit in bringing them to the city at all when any transportation charges are paid. One of the Sting Rays (*Pteroplatea marmorata*) sometimes comes into the market of Los Angeles, and the tails of *Rhinobatus productus* are sometimes preserved and eaten by the Chinese and Mexicans.

The following is a full list of the species now known: *Manta birostris*, the Devil-fish, the largest of all Rays; sometimes come north to San Diego. *Myliobatis californicus*, the common Sting Ray, from Cape Mendocino southward; is destructive to oyster beds, which are always shut in with a sort of picket-fence to keep these animals out. The "sting" of this and other species often produces severe flesh wounds, which may be accompanied by blood-poisoning, and sometimes causes death.[1] *Pteroplatea marmorata*, *Trygon dipterurus*, and *Urolophus Halleri*, all Sting Rays, found

[1] On Thursday week, as D. K. Williams, of Anaheim, was at the landing amusing himself fishing with a net, he was severely stung by a fish known as the Stingaree. He was lifting a few small fish from the net, and among others picked up what appeared to be a small flounder, when he received a fierce sting from the tail of the reptile on his right forefinger. He immediately commenced sucking the poison from the wound, but in a few moments he suffered great agony and became delirious. His friends took him at once to a house and gave him three pints of whisky, which, together with constant attention, brought him through safely in about fifteen hours, and he is now entirely recovered.—*Anaheim Gazette*, April 14, 1871.

south of Point Concepcion only. *Raia inornata, Raia binoculata, Raia rhina,* and *Raia stellulata,* all true Rays, ranging from Santa Barbara or Monterey northward; *R. binoculata* and *R. rhina* as far as Alaska. *R. inornata* and *R. binoculata* are brought into the market of San Francisco in considerable numbers. The latter reaches a length of six feet, the former of two and a half feet. *Rhinobatus exasperatus,* J. & G., in San Diego Bay; *Rhinobatus productus,* and *Rhinobatus triseriatus,* from San Francisco southward, and the Torpedo, *Torpedo californica,* about San Francisco, complete the list.

Only the French in San Francisco can be said to be fond of the Rays, and so long as the present abundance of better fish continues none of them will have any special economic value. The oil in the liver is so little that it is only preserved by the Indians.

199. THE SAW-FISH—PRISTIS PECTINATUS

Of the Saw-fishes, *Pristidæ,* there is at least one species, *Pristis pectinatus,* on the Florida coast. Stragglers are taken occasionally in the Chesapeake Bay, and even farther north. A specimen sixteen feet three inches in length and four feet in width was taken at Cape May in July, 1878. Its saw was four feet three inches long, and was armed with forty-nine teeth. The Saw-fish is, however, rarely seen north of Florida. In the Everglades these fish are said to be exceedingly abundant. In the Saint John's River individuals of all sizes, from one to eight feet in length, are taken as high up as Jacksonville. They are considered by the fishermen to be very much of a nuisance, since they are exceedingly powerful and play great havoc with the shad-nets. As they swim they move laterally, with a swinging motion, the head and snout, which latter is powerfully armed on each side with very strong teeth. Mr. Camps, of New Berlin, told me that he had three cast-iron rowlocks broken off close to the gunwale by a single blow of the saw of a large individual. In the Indian River and its tributaries the Saw-fish is said to be very common, attaining the width of six or eight feet. On the Gulf coast, according to Stearns, it is rather common, being a bottom fish and frequently caught in seines. Stearns states that he once saw a specimen in Saint Andrew's Bay that must have been fully fifteen feet long.

200. THE SHARKS—SQUALI.

There are at least twenty species of Sharks upon our Atlantic coast, some of which are of considerable economic value, while others are simply of interest as being annoyances to fishermen.

The Bone Shark—Cetorhinus maximus.

This species is a native of the Arctic Seas, but has been observed in the Western Atlantic as far south as New York, and on the European coast to Portugal. It is known among our fishermen as the "Bone Shark," and is also called the "Basking Shark" from its habit of basking or remaining quiet for a long time in one place. It is the "Sun-fish" of the Irish and Welsh coasts; the "Sail-fish" of Northern Great Britain, while in the Orkneys it is called the "Hoe-Mother," contracted to "Homer"—the word "Homer" signifying the mother of the spiny Dogfish which is there known by the name "Hoe." The Bone Shark is one of the largest of Sharks, and many years ago a learned dissertation was published by its first describer, Bishop Gunner, of Norway, attempting to prove that this was the species of fish which swallowed Jonah. Yarrell examined a specimen, taken off Brighton, which measured thirty-six feet in length; a large individual was secured in the lower harbor at New York in 1822, while in 1828 a smaller individual obtained in Maine was brought to New York, the dimensions of which were twenty-eight feet in length and sixteen feet in circumference. In September, 1839, an individual thirty-four feet long was stranded

at Eastport, Maine. Storer records the capture of an individual, taken at Provincetown in 1839 and exhibited at Boston, which measured thirty feet and three inches. It is not unfrequently harpooned by the whalers on the Pacific coast. A specimen was examined at Monterey by Jordan and Gilbert.

Very little is known of its habits. It is usually seen in summer, though this is doubtless due to the fact that the fishermen are then in a position to observe them, while in winter the fishermen remain in harbor and would not be so likely to notice their occurrence. Yarrell remarks: "When north winds prevail they are most frequent on the west coast of Scotland, also on the north and west coast of Ireland; if westerly winds, they are not unusual along the whole line of the southern coast."

If these observations are correct, it seems probable that easterly and northerly winds are most favorable for their appearance in the waters of New England.

These Sharks are sluggish in their movements, swimming lazily at the surface, and are said to be so indifferent to the approach of boats that they will allow them to touch their bodies without moving, though, when struck with the harpoon, they swim away with much rapidity and strength.

The only observations upon its food have been made in the vicinity of the Orkneys by Mr. Lowe, who states that its stomach contained a red, pulpy mass, probably the roe of sea-urchins. Linnæus supposed its food to consist chiefly of medusæ or jelly-fishes. The teeth are very small, and the structure of the gill-rakers would indicate that it feeds at the surface, straining its food, like the whalebone-whales. The gill-openings extend from the back nearly to the median line of the throat. The liver of this Shark is very large and yields a great quantity of oil. When they make their appearance in our waters they are usually harpooned by the fishermen, who consider their discovery as a great piece of good fortune. About the middle of last century there is said to have been quite an extensive pursuit of this species in Massachusetts, considerable quantities of oil being taken. In 1848 a vessel, cruising on the coast of Maine for humpback-whales, fell in with many of them off Cape Elizabeth, and secured several of them. Captain Atwood writes: "They are very rare now; once in a great while you will see one. I don't think that more than half a dozen have been caught near Provincetown since 1810. I have heard of as high as twelve barrels being taken from a single one, but have never seen one which yielded more than eight barrels."

In 1835 an individual was caught in a mackerel-net in Provincetown Harbor and harpooned; in 1836 or 1837 a second one was caught in a net, and after being secured the carcass was freed by the fishermen from the net and afterwards drifted ashore in a state of decomposition. After lying on the beach several days a fisherman visited him in order to get a slice to feed to his hens, as is the custom at Provincetown—he supposing it to be a dead whale. Ascertaining what the animal was, he removed the liver and sold the oil in Boston for $103, it having produced five or six barrels. In 1847 a third was captured. The pursuit of this animal is attended with considerable excitement and danger.

Yarrell has recorded[1] the occurrence in the summer of 1870 at Eastport, Maine, of three specimens, twenty-five to thirty feet in length, and also of one taken in 1868, which measured thirty-five feet. Captain Atwood gives the following account of his experience with one:

"Coming one time from Boston to Provincetown with my two boys, I saw the fin of a big Bone Shark. We lowered the boat and pulled up on to him. This was about 1863. I should think he was thirty-five or thirty-eight feet long. It was smooth weather, and I threw the harpoon

[1] Bulletin, Essex Institute, iii, p. 6.

into him and he darted down into the water, and finally he went down again, and kept coming up and going down. I began at four o'clock and tried to haul him up until about supper-time, but could not, and he towed the smack all night. He came on until he got abreast of the oil works at Provincetown, and then he turned and I couldn't get him up; he went about as fast as you would row a dory moderately. The water became shoaler and shoaler until there was eight or ten feet over his back, and then he went towards Beach Hill. We were in the dory and he then came back within a quarter of a mile of the vessel. We went aboard and got something to eat. We got him within six or eight feet of the top of the water and the warp parted and we lost him. I don't think one has been killed here for more than twenty years."

These monsters are occasionally stuffed and carried about the country by showmen, advertised under various high-sounding names.

The Mackerel Shark—Lamna cornubica.

This species, called at Provincetown the "Blue Shark," occurs in the Northern Atlantic, being occasionally seen at various points on the coast of the United States from Newfoundland to Florida, and in the West Indies. In the Eastern Atlantic it is found everywhere from the south of the North Cape, entering the Mediterranean. It has also been recorded from Japan. It is abundant on the coast of Great Britain, where it is known as the "Porbeagle." It also occurs in California.

The ordinary length of this species is from eight to ten feet. They roam about in summer, often several together, preying upon small fish and squids, being particularly fond of mackerel. They are very abundant on the coast of Massachusetts in the mackerel season, and are a great annoyance to the fishermen who use nets, since they become entangled in the twine, destroying the nets by tearing them and rolling them up. Although their livers yield a considerable quantity of oil, formerly prized by curriers, I am unable to learn that they are now regarded as of any practical value.

Storer wrote, in 1847, that the procuring of oil from these fish, which was once a regular business, had at that time been almost entirely abandoned. The practice of saving the oil was a common one, but had been abandoned on account of the apparent decrease in the quantity obtainable.[1] Storer also, in 1846, quoting from Captain Atwood, remarked: "Seven gallons of oil were at that time frequently extracted from the liver of a single fish, while eleven and a half gallons have been taken from one. Of late years this fish has yielded less oil than formerly, so that they are now scarcely worth saving. Formerly a barrel of oil was made from the livers of eleven fish. Captain Atwood tells me that, many years since, his father procured often a barrel of oil from eight livers; not selecting the best, but employing large and small indiscriminately; but now at least one hundred livers would be required to furnish this amount of oil."

The Man-eater Shark—Carcharodon carcharias.

The so-called "Man-eater Shark," the American form of which has been described under the name *Carcharodon Atwoodii*, in honor of Captain Atwood, who sent specimens to Storer, the historian of the "Fishes of Massachusetts," is probably identical with the Great Blue Shark, *Carcharias Rondeletii*, common throughout the Atlantic and Mediterranean, and also known to occur in the Indian Ocean and about the Cape of Good Hope and Australia. In tropical seas it attains an

[1] A Mackerel Shark, measuring nine feet in length, was seen by two men flouncing upon the flats in this harbor on Saturday last, having got entangled in the eel-grass in shoal water, who went to him and cut his throat. His liver *made three gallons of pure oil.—Barnstable Patriot, September 8, 1833.*

enormous size. The British Museum has the jaws of an individual, thirty-six feet in length, taken in Australia. Its mouth is wide, its teeth large, and its jaws strong; it is probable that this species and the Tiger Shark are among the most voracious of their kind.

This is an exceedingly rare species on our Atlantic coast. Storer could learn of the capture of but three individuals from 1820 to 1860, one measuring six feet in length, a second nine feet, and a third thirteen feet. The specimen which he described was captured at Provincetown, and was brought to Boston for exhibition. When first seen it was swimming in ten feet of water on the Long Point side of Provincetown Harbor. A boat's crew having given chase, a harpoon was thrown into it, when it turned toward the boat and seized it with great ferocity near the bows. In the act several of its teeth were broken off. It was eventually killed by being frequently lanced. A specimen was observed at Eastport, Maine, in August, 1872. It is frequently taken in Monterey Bay. A specimen lately taken at Soquel, California, had a young sea-lion whole in its stomach.

Captain Atwood writes: "The Man-eater is rare; I don't remember of having fallen in with but four; these were, with one exception, all caught in mackerel-nets. I suppose about two or three may be caught every year about Provincetown, but fishermen cut them out of the nets and let them go."

The enormous fossil Sharks' teeth which are found in the phosphate beds of South Carolina belong to a Shark closely related to our Man-eater, and, judging from the proportionate size of the teeth, individuals measuring seventy or eighty feet in length cannot have been at all uncommon.

The alleged attacks upon men by Sharks, if any credence is to be attached to them, should doubtless be credited to this species and to the Tiger Sharks. Such attacks are, however, of very rare occurrence, and the stories of them lose nothing of the marvelous in repetition. I quote one of the few accounts which have found their way into permanent record:

"On the 12th of July, 1830, Mr. Joseph Blaney, aged fifty-two, went out in a fishing-boat at Swampscot, Massachusetts, when a Shark overset his boat and killed him. [This Shark must have been extremely ferocious. Mr. Blaney went out into the bay in one of the large Swampscot boats, which he left, and in a small boat rowed away, alone, to fish. After some hours he was seen to wave his hat for assistance. Another boat immediately started toward him, and presently the fish was seen to slide off, Mr. Blaney still remaining in his boat. But the Shark renewed the attack, carrying down the boat before the other could arrive. It came to the surface bottom up, and the unfortunate man was no more seen.]"[1]

The Sand Shark—Odontaspis littoralis.

This species, known also on the coast of Maine as the "Shovel-nosed Shark," and at Provincetown as the "Dogfish Shark," is found on our coast from New England southward to Charleston, and is believed by Günther to occur also about Australia and the Cape of Good Hope. Little is known of its habits or movements; it is occasionally found straggling upon the shores at Cape Cod or entangled in the mackerel-nets. It is a sluggish species and hugs the bottom closely, feeding upon crabs, lobsters, and squids. The ordinary length is five or six feet, but about Nantucket they grow much larger, attaining the length of nine or ten feet and the weight of two hundred pounds or more. It is a favorite amusement of summer visitors at Nantucket to fish for them, and ten or twelve are frequently taken by one man in a day. Their bodies are used for manure, while the livers are saved for the oil which they contain. The liver of a large individual will yield a gallon of oil, worth about seventy-five cents.[2]

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[1] Lewis & Newhall.: History of Lynn, p. 395.

[2] Jackson: Proceedings Bost. Soc. Nat. Hist., vi, 1857, p. 259.

The Thrasher Shark—Alopias vulpes.

The Thrasher Shark, known in Europe as the "Fox Shark," and to our fishermen most usually as the "Swingle Tail," is found in the Northern Atlantic and in the Mediterranean, and also off California. It is one of the most grotesque of sea animals, the upper lobe of the tail being exceedingly long, curving upwards and resembling in form the blade of a scythe.

The Thrasher attains the length of fourteen or fifteen feet and the weight of five hundred pounds. An individual was taken in November, 1864, in the harbor of Marion, Massachusetts, which was thirteen feet long and weighed four hundred pounds. This species is quite common all along the coast of New England, and is frequently an annoyance to the mackerel fishermen by becoming entangled in their nets; otherwise it is quite harmless. It is found also in California.

The tales which are current regarding the ferocious attacks of these Sharks upon whales are apparently without foundation.

These animals feed upon fish, and it is said by the fishermen that they kill them by blows of the long, flexible tail. When they become entangled in the nets, or are caught on hooks, they *make a powerful resistance and cause the fishermen much trouble. Their livers are sometimes* used by the oil-makers. There is a belief widely current to the effect that the Thrasher Shark, singly or in companies, is accustomed to attack whales. This belief is undoubtedly founded upon errors of observation, as I think I have demonstrated in the chapter relating to the Sword-fish.

The Hammer-head Shark—Sphyrna zygæna.

This species is found all along the coast from Cape Cod southward, and, indeed, in tropical and subtropical seas the world over; it may be easily recognized by the curious form of the head, which is broad, flattened, and laterally elongated into two arms, which have been compared to the arms of a balance. It attains the length of seven or eight feet. Dillwyn obtained a female *specimen at Swansea, which contained thirty-nine young ones on the point of birth.*

The Hammer-head Shark is not uncommonly taken in summer, but is of no special importance. In Mitchill's "Fishes of New York," under the head of this species it is stated: "Three Sharks of the Shovel-nosed species were taken (in September, 1805) in a net by Mr. Joshua Turry, of Riverhead. The largest was eleven feet long. On opening him, many detached parts of a man were found in his belly; these were collected and buried; there was also found a striped cotton shirt, patched on the sides and sleeves with bright-colored pieces."[1]

It seems probable that the Shovel-nosed Shark referred to in the above paragraph was rather a *Carcharias*, since these Sharks are often called "Shovel-nosed Sharks" by the coast fishermen.

Bonnet-headed Shark—Sphyrna tiburo.

This species is found in our waters in company with the preceding species, and when both are known to the fishermen, the names "Hammer-head" and "Shovel-nosed" are used indiscriminately for both. Its distribution as at present understood is less extensive, since it has been found only in the warmer parts of the Atlantic and on the coast of China. It is very common on our South Atlantic and Gulf coast, where it is often distinguished as the "Bonnet-head." The habits of the two species are doubtless very similar.

The Blue Shark and the Dusky Shark—Carcharias cæruleus and Carcharias obscurus.

These two species, which are somewhat common in our waters south of Cape Cod and which can be distinguished apart only by trained observers, attain the length of twelve or fifteen feet,

[1] Transactions of Literary and Philosophical Society of New York, i, p. 48.

and are occasionally taken in nets. They are of no special value, and cause much annoyance to the fishermen. An individual taken at Wood's Holl, Massachusetts, in July, 1875, measured nine feet seven inches, and weighed three hundred and eighty pounds, the liver weighing thirty-eight pounds. It had in its stomach a bluefish of five pounds' weight. These two species feed upon mollusks as well as upon fish. Individuals examined by the Fish Commission were found to contain bluefish, flounders, crabs, lobsters, and quantities of a small species of a bivalve shell, *Yoldia sapotilla*.

The Black-finned Shark—Isogomphodon maculipinnis.

This species resembles in shape the Blue Shark, from which it may be distinguished by its lighter color and the presence of a prominent black spot upon the tip of each fin. The species is found in the tropical parts of the Atlantic and Indian Oceans and on the Pacific coast of Central America. It was first discovered on our coast in 1875, when several specimens were taken at Wood's Holl, Massachusetts.

The Tiger Shark—Galeocerdo tigrinus.

This is a species which is found throughout the Atlantic and Indian Oceans and on the coast of Japan. It was first noticed in our waters by Captain Atwood, who obtained specimens at Provincetown, and has since been observed occasionally. It is one of the most active and graceful of Sharks, as well as one of the most ferocious. Its teeth are like razors. In the stomach of a specimen taken by Captain Atwood at Provincetown, nearly a whole full-grown sword-fish was found; ten or twelve wounds in the skin of the Shark gave evidence of the contest that must have occurred. It feeds upon mollusks as well as upon other fishes. A specimen caught at Wood's Holl in 1871 contained large univalve shells, *Buccinum undatum*, and the sea-snail, *Lunatia heros*.

The Smooth or Blue Dogfish—Mustelus canis.

The Smooth Dogfish of our waters, *Mustelus canis*, is without doubt specifically identical with one of the common European species, *M. vulgaris*. The American name has, however, the right of priority. Hitherto, only a single species has been recognized upon Atlantic coasts. It is quite abundant on the coast of Southern New England. It feeds upon crabs, lobsters, and other bottom-loving invertebrates, its smooth pavement-like teeth being adapted for crushing the thick shells of these animals rather than for seizing and holding active fishes.

In Bermuda this fish is known as the "Nurse Shark," and is highly esteemed by the negroes as food, and is also an important bait in the local fisheries. At Folkstone, England, they are dried, and go by the name of "Folkstone beef."

The Horned or Spiny Dogfish—Squalus acanthias.

This species is found in the North Atlantic, occurring on the coast of Europe from the North Cape to the Mediterranean, and in our own waters south to New York. On the west coast it ranges south to Santa Barbara. Little attention has been paid to its habits. I cannot do better than quote fully the observations of Captain Atwood, who writes:

"This Shark is the most common one upon our coast. I have seen it at Gay Head, Martha's Vineyard, but know nothing further about its southerly limits. Both above and below Cape Cod it is abundant, and is found all along the coast of Massachusetts, Maine, Nova Scotia, and the Gulf of Saint Lawrence. I myself have never seen them farther north than the Magdalen Islands and the east coast of Cape Breton Island, but reliable accounts say that it is found on the southern coast of Newfoundland. As the Dogfish appear at Provincetown a little while after the

mackerel, and disappear shortly before them, I judge that they probably need warmer water than that fish, and therefore do not probably go quite so far north. When they first appear they are in great abundance; the females always excel in numbers the males; but in the early part of the season all are females, and all have young in some stages of development, though not in every stage, there being seldom any between the young just forming and those nearly grown. The gravid females may be found with the young in some stages of development during the whole season. The mature male weighs five or five and a half pounds, rarely as much as six pounds, while the female attains the weight of eight or eight and a half pounds. In spring they are poor, and their liver is of a dark color and lean; but in autumn it is quite fat and large, and the amount of oil does not increase proportionately with the enlarged size of the liver, but rather decreases. In the *Gadidæ*, on the contrary, the liver when in poor condition affords no oil. Fat is also found in the flesh of the Dogfish, which is sometimes used for fuel, burning well when dried."[1]

The same authority also writes: "When I first began to go fishing, in 1810 to 1820, the Dogfish fishery was considered one of the most valuable fisheries that we had around the shore. They appeared here in the spring, and were very plenty, and would last a day or two and then all would be gone. Then you would not see a Dogfish again all summer; but about the 10th, or middle of September they came to us again returning south. They would stay into November, and during that time the fishermen would get—a man and a boy—all the way from eight, ten, to fifteen barrels of oil. Twenty-five years ago we would occasionally see Dogfish in the summer. The last fifteen years they have been here all summer. During the war they were plenty all summer and the livers sold for one dollar a bucket, and now they are not worth but twenty and twenty-five cents. The female Dogfish is a good deal the biggest. I have known of Dogfish to be with full-grown young in November."

The annoyance which is caused by the presence of Dogfish may be judged from the fact that a trawl line, upon which were five hundred hooks, set by the Fish Commission party of Gloucester in 1878, had nearly one hundred and forty hooks bitten off by the Dogfish at one setting.

About Cape Ann the Dogfish do not come near the shore. Capt. S. J. Martin, an experienced fisherman, assures me that he has never seen one within three miles of land off Gloucester. They leave Cape Ann, for the most part, before October, and remain on George's Bank until December. They go upon the shoals of George's about the 20th of May, and stay all summer in the shoal water, especially, at a depth of thirty-five to forty fathoms, on the western part.

In addition to the oil yielded by these little Sharks, the skin is of considerable value, and will doubtless in future be more highly prized than it is at present. It is used by the fishermen to polish their metallic mackerel-jigs, and sometimes in polishing the fancy wood-work on shipboard. If properly brought into notice, the Dogfish skins would perhaps be used to advantage in many departments of metal-working.

In Southern New England this fish is called the "Bone-fish," in the Orkneys, the "Hoe."

Couch remarks: "It is the most abundant of the Sharks, and is sometimes found in incalculable numbers, to the no small annoyance of the fishermen, whose hooks they cut from the lines in rapid succession. I have heard of twenty thousand being taken in a seine at one time; such is the strength of instinct that little creatures, not exceeding six inches in length, may be found in company with the larger and stronger, following schools of fish, although at that time it is impossible that they could be able to prey."

[1] Proc. Bost. Soc. Nat. Hist., x, 1864–'66, pp. 81–82.

THE NURSE SHARK OR SLEEPER—SOMNIOSUS MICROCEPHALUS.

This species, also called by our fishermen the "Gurry" or "Ground" Shark, is a native of the Arctic Seas, but on our coast ranges south to Cape Cod, and in the Eastern Atlantic at least to England, while in the Pacific it has been observed from Puget Sound northward. The name "Gurry Shark" refers to its habit of feeding upon the refuse fish thrown overboard from the vessels.

This species is occasionally observed in Massachusetts Bay, especially when the carcasses of whales are floating about. Scoresby writes, in his work on the Arctic Regions: "This Shark is one of the foes of the whale; it bites it and annoys it when alive and feeds on it when dead. It scoops hemispherical pieces out of its body nearly as big as a person's head, and keeps scooping and gorging lump after lump until the whole cavity of its belly is full. It is so insensible of pain that, though it has been run through the body with a scythe-knife, yet I have seen it return to its banquet upon the whale at the very spot where it received its wound. Besides feeding upon whales, these Sharks also eat small fishes and crabs. The sailors imagine that it is blind because it pays not the least attention to the presence of a man, and is, indeed, so apparently stupid that it never draws back when a blow is aimed at it with a knife or lance."

Captain Atwood writes: "We don't see them very often about Provincetown, but sometimes they are seen in the bay. They would eat a whale if one were sunk there, and they eat halibut off the trawl. I have hauled up halibut and like enough the back would be all eaten off. Some of them are quite large. Robert E. Smith, of Barnstable, got one about fifteen feet long, half of whose liver filled a barrel. I don't know of their having been taken here for a good many years. The liver furnishes five or six gallons of oil; in one case a single half lobe filled a flour-barrel and yielded fifteen gallons of oil."[1]

201. THE SHARKS OF THE PACIFIC COAST.

By DAVID S. JORDAN.

The following is a list of the Sharks known from the Pacific coast. Of these, the three very large species, *Cetorhinus maximus*, *Carcharodon carcharias*, and *Somniosus microcephalus*, are valued for the oil in their livers, but are captured rather by accident, by whalers and fishermen, than by design. They are never made objects of pursuit. The Sharks *Squalus acanthias*, *Galeorhinus zyopterus*, and *Heptranchias maculatus* are regular objects of pursuit for their oil, and in the case of *Galeorhinus zyopterus* for their fins also. The young of several other species are dried by the Chinese, who utilize everything which their brethren on the railroads will eat. Others are used as craw-fish bait, and for similar purposes.

LIST OF SHARKS OF THE PACIFIC COAST.

Squatina angelus Duméril. Angel-fish, Angelo or Squat. From San Francisco southward. Not rare.

Heptranchias maculatus (Ayres) Grd. Shovel-nosed Shark. Monterey northward.

[1] A large winter Shark was driven ashore in the storm of the 20th instant at Cotuit Port. It was fifteen feet in length, and his liver made fifteen gallons of oil.—*Gloucester Telegraph*, February 2, 1850.

The schooner "Cosmos," of Swampscot, landed a formidable Nursefish at Portsmouth recently. It measured sixteen feet in length and weighed about twenty-five hundred pounds, and was caught on a common trawl line.—*Cape Ann Advertiser*, March 11, 1881.

Hexanchus corinus J. & G. Monterey northward.
Heterodontus Francisci (Grd.) Dum. Leopard Shark. Point Concepcion southward.
Scylliorhinus ventriosus Garman. Ground Shark. From Monterey southward.
Alopias vulpes (Gmel.) Bonap. Thrasher. Monterey Bay.
Isurus sp. San Pedro.
Lamna cornubica (L.). Monterey Bay.
Carcharodon carcharias (L.) J. & G. Man-eater Shark. Monterey Bay and southward.
Cetorhinus maximus (L.) Blainv. Ground Shark. Monterey Bay northward.
Sphyrna zygæna (L.) Raf. Hammer-head Shark. San Pedro.
Carcharias glaucus (L.) J. & G. Blue Shark. San Francisco and northward.
Carcharias lamella J. & G. Bay Shark. San Diego.
Galeocerdo tigrinus Müller & Henle. San Diego.
Galeorhinus zygopterus J. & G. Oil Shark. San Francisco and southward.
Triacis semifasciatus Grd. Cat Shark. San Francisco and southward.
Triacis Henlei (Gill.) Putn. *Monterey and northward.*
Mustelus californicus Gill. Dog Shark. San Francisco and southward.
Squalus acanthias L. Dog-fish; Spinarola. Santa Barbara to Alaska.
Somniosus microcephalus (Bloch) Gill. Puget Sound northward.

Shovel-nosed Shark—Heptranchias maculatus.

This species is usually known as the "Shovel-nosed Shark." It reaches a length of three to five feet. It ranges from Monterey Bay northward, being most abundant in Northern California. About Eureka, on Humboldt Bay, it is pursued for its oil, which has some value. For a discussion of this, see the account of Humboldt County, California.

Oil Shark—Galeorhinus zyopterus.

This species, which is closely allied to the common Tope of Europe, is known in California as the "Oil Shark" or "White Shark." It reaches a length of five to six feet and a weight of thirty to forty pounds, the average being about twenty. It ranges from Tomales to San Diego, being especially abundant in spring about Monterey and Los Angeles, especially at Soquel, Monterey, Westminster, and Newport. It feeds on other fishes, herring being the best bait. It brings forth its young alive from April to August, entering small bays and lagoons for this purpose. At these times it is chiefly taken. It is valued for the oil in its liver and for its fins. A liver makes from one-half to one gallon of oil. The fins are sold to the Chinese, who dry them, and removing the skin and flesh extract from the rays a fine, clear-white gelatine, which is highly valued by them for making soups. This is the only American species the fins of which they consider valuable.

Dogfish—Squalus acanthias.

This species is everywhere called the "Dogfish." The Italian fishermen also call it "Spinarola." It reaches a length of about three feet. It ranges from Alaska southward as far as Santa Barbara, but its abundance is from Puget Sound northward among the islands. It lives especially in deep or quiet bays and channels, coming into shallower waters in pursuit of schools of herring, smelt, or salmon. It feeds on anything, even its own young, but the herring make the chief part of its diet. The young are brought forth in June in Puget Sound. It is valued for its liver, from which dogfish oil is extracted.

202. THE LAMPREYS—PETROMYZONTIDÆ.

In the fresh and brackish waters of the United States occur several species of the Lamprey family.

NAMES.—The habits of these fishes are not well understood, and in the present discussion we shall be obliged to rely to a considerable degree on the observations of European zoologists. In the United States the fishes, of whatever species, are generally known as "Lampreys" and "Lamper Eels," these names being also in use in England, where one of the smaller species, *P. branchialis*, is also known as the "Pride," "Prid," or "Sandpiper." The name "Nine-eye" is also common in England, a name which reappears on the continent in the "Neunauge" and "Neunaugel" of Germany and Austria, and the "Nejon ögon" of Scandinavia. This curious name had its origin in the eye-like appearance of the circular branchial openings, of which a *considerable number appear on* either side of the head. In the common "Nine-eye" of England, however, there are only seven, and even if the eye be counted only eight, eye-like circles upon each side. In Germany the name most commonly in use is "Pricke" or "Bricke," while in France "Lamproie" is their usual appellation, and in Italy "Lampreta."

DISTRIBUTION.—The Lampreys are almost the least specialized of fishes. Although in form resembling the eels, *they belong to a very different group*, which by Gill and others of our best authorities has been considered a distinct class, and are not even entitled to be called fishes. So slight has been the progress in the scientific study of the Lampreys, that but little can be definitely stated about their geographical distribution, excepting that they occur in the fresh waters and along the coasts of the temperate regions of both hemispheres. The largest and best known species, and the only one which has at present any commercial value, is *Petromyzon americanus*, by *most authorities believed to be identical with the P. marinus* of Europe,[1] which occurs in the streams and estuaries of our eastern coast from Nova Scotia as far south at least as Cape Hatteras.

HABITS.—The key to the habits of the Lampreys is found in the peculiar arrangement of their mouth. In *P. marinus*, according to Emile Blanchard, this is completely circular and forms a great sucker enormously capacious, surrounded by a fleshy lip studded with tentacles and supported within by a cartilaginous framework. This mouth is covered over its entire interior *surface with strong teeth* arranged in concentric circles, some single, others double, the larger occupying the central portion, and the smaller forming the exterior rows. A large double tooth, situated above the aperture of the mouth, indicates the situation of the upper jaw; a large cartilage, supporting seven or eight great teeth, represents the lower jaw. The tongue also carries three large teeth, deeply serrated upon their edges.

The structure of the intestine, which, as in the Sharks, is provided with an extensive spiral valve, indicates that these animals are chiefly carnivorous in diet. They are said to feed upon worms, insects, and decaying animal matter. Dr. Benecke, of Königsberg, and others have found their stomachs full of the eggs of fish. The structure of the mouth, however, would teach us, even in default of observations upon their customary mode of feeding, that they are semi-parasitic in their habits, attaching themselves to large fish by suctorial action, and, while attached, tearing the flesh of the fish with their marvelous mincing machine, which is composed of the teeth within the circular mouth, while they suck the blood of their victim. They are often found attached to the larger fishes, such as shad, sturgeons, and Sharks.

Captain Atwood states that small Lampreys of a bluish color are found attached to various

[1] GÜNTHER: Catalogue of Fishes of the British Museum, viii, p. 501.

species of fish in Massachusetts Bay, such as cod, haddock, and mackerel. They cling to the side of the fish beneath the pectoral, and suck its blood until the flesh becomes as white as paper.

There can be but little doubt that to the Lampreys may be credited an immense destruction of the various food-fishes which enter estuaries and rivers. It is by no means uncommon for fishermen to find them attached to halibut and other large species caught at sea. Lampreys are found far inland, ascending most of the creeks and rivers of Central Europe and of temperate North America far toward their sources. In fact the distances from the sea at which the so-called "sea Lamprey" of Europe is constantly found are so great, when their feeble powers of locomotion are considered, that Dr. Günther in his essay on the fishes of the Neckar was induced to advance the theory that they are carried from the sea to the river sources by the shad, salmon, and other fish to which the Lampreys attach themselves. This view is combated by Blanchard, who claims that no one has ever seen Lampreys attached to salmon. If I am correctly informed, salmon are largely annoyed by Lampreys in the United States, but it seems hardly necessary at present to accept Günther's theory in the fullest extent, since the Lamprey is apparently not much inferior to the eel in powers of locomotion, and the eel, it is well known, accomplishes long migrations without apparent inconvenience.

It has been customary among writers upon fishes to class the Lampreys among the migratory fishes, and to describe the migrations of the sea Lamprey as beginning in the spring, when they are supposed to ascend the rivers for the purpose of spawning in their headwaters. This theory seems at present hardly tenable; so little, however, is known of their habits that the theory cannot be pronounced absolutely incorrect. There are, however, certain species of Lampreys in Europe which are believed to live entirely in fresh water. A similar statement can most positively be made regarding our species inhabiting the Great Lakes and other inland waters of North America. On the other hand, many of the sea Lampreys remain in salt and brackish water throughout the year. There appears, however, to be excellent evidence that some of the Lampreys move from brackish water into fresh for purposes of spawning.

Benecke, speaking of the habits of the river Lamprey of the Baltic, remarks: "Concerning the habits of 'Nine-eyes' in the sea nothing is known. In summer they make their way from the Baltic into the Kurisches Haff and the Frisches Haff, and toward the end of September begin to ascend the rivers, and are caught in great numbers in baskets and pots. The ascent continues until January. In the upper reaches of the rivers they make their appearance in the early spring, and spawn in April and May in small schools in shallow places, where the water flows rapidly over shingly bottom. The act of spawning has been observed by us from year to year in the passage between the bridges at Braunsberg. After the eggs, which are one millimeter in diameter, grayish-yellow in color, and entirely opaque, have been deposited in little masses, the Lampreys die.

"The development of the spawn is extremely dependent upon the weather, so that during many years only a very small brood of young fishes makes its appearance. The young of this species have been found by August Müller in the Oder and the Alle, and in the latter (!) the drying up of one of its tributaries near the mill at Pinne gives an opportunity every year to collect hundreds of them in the bottom mud. They are never found partially grown, and we must believe that they go back to the sea, there to attain their full size."

REPRODUCTION.—Concerning the breeding habits of the brook Lamprey, *P. planeri*, Benecke writes: "The brook Lampreys, like the allied species, feed upon little animals, and are found in almost all the clear brooks in Prussia, seeming never to migrate to the sea, although Yarrell claims that he has found them there. The clear gray or grayish-yellow eggs, which are one millimeter in thick-

ness, are deposited in March or April. The adult fish gather themselves together in companies of from ten to fifty individuals to spawn in water of little depth, where the current flows swiftly over rough ground. In close proximity to each other they cling with their mouths to the bottom, and their bodies streaming out in the current squirming like the bodies of snakes. Every once in a while the observer can see a male, easily recognizable by its size and black color, seize upon one of the females with its suctorial mouth, and therewith firmly attaching itself to her close behind the head. The two then extend themselves with a powerful backward squirm, and while the male, with a half turn of its body, brings his abdominal aperture close to that of the female, a part of her spawn may be seen flowing forth in a clear, semi-opaque stream. This action is repeated until the female has deposited all of her eggs. The young Lampreys, when hatched, burrow in the mud. They require a period of four or five years before they attain the length of twenty centimeters."

The development of the Lamprey is extremely remarkable. It was first worked out thoroughly by Prof. August Müller in 1856.[1] The young was formerly considered to be a member of a distinct genus, *Ammocœtes*. The young of the brook Lamprey, *P. planeri*, which, in a general way, correspond to those of other species, are thus described by Professor Benecke: "They are tawny yellow, without any trace of silvery hues, and have half-moon shaped, toothless mouths, not intended for suctorial uses. Their small eyes are hidden deeply under their thick skins, and hardly visible. Their gill-openings lie in a deep furrow. The head is small and pointed, and the fins continuous."

It is a curious fact that as early as 1866 Leonhart Boldner, of Strasbourg, investigated and thoroughly understood the development and metamorphoses of the Lamprey, as is indicated in the following paragraph, translated from his work upon the water-birds, fishes, and other aquatic animals of Strasbourg:

"From August to December, Lampreys with eyes are not often seen and are rarely taken, but blind Lampreys are found throughout the entire year. The Lampreys with eyes and the blind Lampreys are all of the same kind, for the young from the very beginning are all blind, and bury themselves at once in the mud as soon as they make their escape from the eggs. The blind Lampreys develop no eggs until they develop their eyes."[2]

Like the eel, the Lamprey was formerly believed to be hermaphrodite.[3]

As far as I am aware, few observations are on record which indicate the date of the spawning of the Lampreys in this country. *P. niger* spawns in early spring. Wittmack, in his excellent work upon the "Fishery Statistics of Germany," states that *P. marinus* spawns at Hameln in June, and in the Rhine, at Zurich, in March and April; *P. fluviatilis* in various parts of Northern Germany, chiefly in March, April, May, and June, though in the Kurisches Haff also in November, December, and February. In Bavaria their spawning season is from March to June; in Austria in April and May, and in Switzerland in March and April. *P. planeri* is said by the same author to spawn in Pomerania in May; in the Rhine Provinces in March and April; in Hanover in May and June; in Gotha in March and April, and in Lower Bavaria in May, June, and July; in the Tyrol in March, April, May, and June, and in Switerland in March and April. In the rivers of Connecticut, where a lamprey fishery is still carried on, Lampreys are reported to be abundant in May and June; and it is probable that these months are included within the period of spawning. The artificial propagation of the Lamprey was first successfully accomplished on the 24th of May, 1879, when M. Frauen, employed by the German Fishery Union in gathering sturgeon-eggs in

[1] MÜLLER: Archiv für Naturgeschichte, 1856, p. 325.
[2] VON SIEBOLD: Süsswasserfische Mitteleuropas, p. 378.
[3] SIR EDWARD HOME in Philosophical Transactions, 1815, p. 266.

Schleswig-Holstein, fertilized the eggs of the river Lamprey and placed them in a breeding box. Between June 3 and June 16, many young were hatched out, and on July 17 the entire contents of the breeding box escaped.[1]

As has already been stated, it requires four or five years for the larval Lamprey to undergo its metamorphoses and become capable of reproducing its kind. The sea Lamprey, *P. marinus*, often attains the length of three feet; but those species which are found only in fresh water are usually much smaller.

The name *Petromyzon* signifies "a stone-sucker," it being a common habit of these animals to cling to stones and pebbles. In swift currents this habit is of great importance to them, since it enables them to hold their own where their swimming powers would often be severely taxed. It is stated by careful observers that they have some way of transporting stones, and that they build nests, or rather circular fortifications of stonework, around the crevices in which they lurk. As may be inferred from what has already been said of the manner in which they prey upon other fishes, Lampreys are among the most troublesome enemies of many large species. Günther states that salmon have often been captured in the middle courses of the Rhine with marine Lampreys attached to them. Milner, in his "Report on the Fisheries of the Great Lakes,"[2] remarks: "A parasite that troubles the sturgeon is the Lamprey Eel, *Petromyzon argenteus*, Kirt., which is found very frequently attached to the skin. The circular scars and raw sores sometimes found upon the sturgeon, and attributed to this cause by the fishermen, are correctly accounted for in this way. It is probable that their natural food is the slime or mucus exuded in abundance from the pores, but they frequently retain their hold upon a spot until they have eaten through to the flesh, and deep ulcerous cavities occasionally result from the sore."

ECONOMIC USES AND CAPTURE.—The Lamprey was formerly highly esteemed as an article of food, and in early days is said to have constituted an important dish in certain civic feasts of Europe. It was once the custom to drown Lampreys in wine and then to stew them. This process was supposed to impart a higher flavor to the flesh. It is stated by Lacépède that King Henry I, of England, came to an untimely end by too full a repast of Lampreys. At the present time, in Germany and France, they are cooked in earthenware jars with vinegar and spices, and are frequently seen among the relishes and *hors-d'œuvre* brought upon the tables as a preliminary course. They are also highly esteemed in many other parts of the continent. At present in this country Lampreys are but little prized, except in certain portions of New England, particularly along the Connecticut River. Col. Theodore Lyman, in his report as fish commissioner of Massachusetts for 1876,[3] states that the Lamprey Eel is a fish greatly esteemed by the country people of Massachusetts, and one which was formerly taken in almost incredible numbers in the Merrimack. It was found as far north as Plymouth, New Hampshire, and by the Connecticut River also it passes into the same State. When the Saint Lawrence dam, in 1847, was first completed, several cart-loads were daily taken by one man for a considerable period. In 1840 Mr. Joseph Ely took thirty-eight hundred in one night at Hadley Falls. It was then the custom of the country for each family to salt down several barrels of Lampreys for winter use. "Now, in 1866," he continues, "this valuable fish has become nearly extinct in both rivers." This remark should be interpreted as applying simply to the headwaters of the Connecticut, since in the tributaries of its lower stretches there is still a considerable lamprey fishery and a large local consumption.

Mr. George Lyon, of Bridgewater, Connecticut, writes under date of August 25, 1879:

[1] Circular der Deutschen Fischerei-Verein, 1879, pp. 135, 136, 159.
[2] Report United States Fish Commission, part ii, 1874, p. 74.
[3] Page 40.

"Previous to the building of the dam over the Housatonic at Birmingham, Lampreys were taken in large quantities as far up the river as the falls in the town of New Milford; now none are seen above the dam. Then, standing over the falls on shelving rocks, one could hook them, as they clung to the rocks with their suckers, by means of a large sharp hook fastened to a long pole, this hook being imbedded in the holes in the sides of their necks. Many people formerly salted barrels of them for their own consumption. Their use at present has much decreased, owing to the disturbance in the fisheries caused by the building of the dams. Those now used in the vicinity of Bridgewater are taken in the Housatonic at Birmingham, and during the months of May and June are peddled through the country by the people who catch them."

Mr. N. M. Muckett, of Lakeville, Connecticut, states that in that vicinity the annual average catch is about two thousand fish, the implement of capture used being a pole about six feet in length with a hook in its end. The fisheries are located in Salmon River about two miles from the Connecticut, just above tide-water, and the Lampreys sell in the markets of the adjoining villages at an average price of five dollars a hundred.

Mr. M. A. Hart, of Riverton, Connecticut, says that thirty years ago, and before, Lampreys were found in the Farmington River in the vicinity of Riverton, but have long ago been exhausted. Quantities are sold in the city markets of Southern Connecticut, chiefly obtained in the Connecticut River in spring and early summer. They are easily caught with the hands, and fishermen capturing them in this way always use mittens.[1]

Mr. C. M. Hunt, of Northville, Connecticut, states that in New Milford large quantities are consumed in May and June which are caught in the Housatonic at Birmingham. Before the dam was built they were caught everywhere in the Housatonic and the small streams which are its tributaries.

203. THE HAG-FISHES—MYXINIDÆ.

The "Slime Eel," *Myxine glutinosa*, is found on the Atlantic coast north of Cape Cod, and in the deeper water even further south. It occurs also on the coasts of Northern Europe. It is a great annoyance to the fishermen, whose baits it devours, and who entertain for it a superstitious dread. Little is known of its habits, and its importance to man is very slight. Jordan writes:

"The Hag-fishes (*Myxinidæ*) are represented along the California coast by one species, *Polistotrema Stouti*. It is most abundant in Monterey Bay, where it is very destructive to fishes caught

[1] The Hartford (Conn.) "Post," in June, 1876, contained the following paragraph:

"CURIOUS HABITS OF LAMPREY EELS.—Two gentlemen from Granby, Connecticut, Messrs. Dewey and Goodrich, were in town last week on a visit, and took away with them on their return one hundred and ten Lamprey Eels, which they captured in the creeks hereabout. The Eels were all of good size, sixty-two of them weighing one hundred pounds. These Eels are esteemed to be a great delicacy by the people of Granby and neighborhood, and are held to be worth twelve cents apiece, or they offer to exchange a barrel of pork for a barrel of cured Eels. The method of taking these Eels is quite novel. They are found only in shallow water, with stony or gravelly bottom, and the fisherman goes provided with a large bag of netting, the mouth of the bag being distended with a hoop, and an instrument of iron about eighteen inches long terminating in a hook.

"The Eels have what are called nests, made by heaping up stones in a circle of about eighteen inches in diameter. These stones they place in this position by fastening their sucker mouths thereon and moving themselves laterally, drawing the stones along with them. Inside this circle of stones lie usually from three to five Eels, parallel with one another, their heads all in one direction and each Eel made fast by suction to a stone. The bold fisherman approaches them from behind, and, skillfully putting his hook under an Eel, he suddenly brings it up with such force that it penetrates the hide, and brings out the fish, when, after two or three flourishes in the air to get him in the right position, he is deposited in the bag. Each Eel in the nest is in turn made the subject of a similar operation, the creatures often holding on to the stone with such tenacity as to bring it out of the water with them, when the aërial flourish causes it to become detached and to fly to a considerable distance.

"These Eels, it is said, are wholly free from bones save the backbone, which is removed in dressing, and when salted for a few weeks and fried make an article of food second to none in the way of fish."

in gill-nets. It fastens itself on the eyes, or especially the gills, of fishes and works itself into the inside of the body, where it devours all the flesh without breaking the skin, so that the fish is left a mere hulk of head, skin, and bones. Every gill-net in summer at Monterey has more or less of these empty hulks (*Sebastichthys, Ophiodon, Rhacochilus, Paralichthys,* etc.) in it. It is thought by the fishermen that the Hag-fish will eat a fish of five or six pounds weight in a single night. When a hulk is taken out of the water with a Hag-fish in it, the parasite will scramble out with great alacrity. They reach a length of fourteen inches."

204. THE LANCELETS—BRANCHIOSTOMIDÆ.

The Lancelet, or Amphioxus, *Branchiostoma lanceolatum*, interesting as being the lowest and least specialized of vertebrate animals, has been found at the mouth of the Chesapeake, at Flatts Village, Bermuda, and at San Diego, California.