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1874. Report on the fisheries of the Great Lakes; the result of inquiries prosecuted in 1871 and 1872.

In United States Commission of Fish and Fisheries, Part II, Report of The Commissioner for 1872 and 1873. Appendix A. The Fisheries of the Great Lakes, and the (species of Coregonus or white fish.)

Milner Report
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I.—REPORT ON THE FISHERIES OF THE GREAT LAKES; THE RESULT OF INQUIRIES PROSECUTED IN 1871 AND 1872.

BY JAMES W. MILNER.

A.—INTRODUCTORY REMARKS.

I.—OUTLINE OF OPERATIONS.

In carrying out the work allotted to me in the region of the great lakes, in 1871, I made a tour of the entire shore of Lake Michigan and the islands, visiting nearly every fishing locality, gathering testimony of the fishermen as to the present condition of the fisheries, its comparison with former years, the kinds of nets in use and their effect on the numbers of the fish, and the opinion of the net-owners as to the influence of protective legislation. The visit to the fishing-grounds afforded opportunities for acquiring information in the modes of fishing, the species captured, and some knowledge of their habits, of which I availed myself as far as I could. A collection was made, embracing nearly all the species of the lake, which was, unfortunately, lost with the building of the Academy of Sciences in the great fire of that year in Chicago.

On being notified by you that the revenue-steamer Johnson would afford facilities for dredging, I went on board with a dredging outfit in September, after returning from the north shore of the lake, and remained with the steamer during a cruise of two weeks, dredging whenever it was possible, though the stormy weather during the trip prevented as extensive work as was desirable. Enough was done, however, to obtain a knowledge of the general distribution of invertebrate forms throughout all depths, and a collection of crustaceans, mollusks, and insect larvæ secured, which met the same fate as the collection of fishes in the fire. The late Dr. Stimpson had previously identified most of the species as the same as those of his own collection on a dredging expedition in 1870. The general distribution of white-fish food throughout the lake, however, was sufficiently established.

In 1872 localities on Lake Superior were visited, a collection of the fishes obtained, and ample notes of their habits recorded. The fisheries of Detroit River and a portion of Lake Erie were examined, and information gathered with reference to fishing interests, and specimens of the fishes preserved. From Detroit River a quantity of white-fish spawn was obtained and impregnated and placed in the troughs of Mr. N. W. Clark's hatching-house at Clarkston, Mich., with which gentleman a contract

was made for their care until ready to be turned into the waters. Arrangements were also made with Mr. N. W. Clark, and Mr. H. F. Dousman, of Waterville, Wis., for the care of the salmon-eggs furnished for the States of Michigan and Wisconsin.

A correspondence was opened with gentlemen of Wisconsin, who used their influence in obtaining a sufficient appropriation from the State for the expenses attending the introduction of salmon into its waters. Dr. J. W. Hoyt, Dr. I. A. Lapham, Hon. L. J. Farwell, and Mr. H. F. Dousman cordially assisted the movement and obtained the required aid.

During the legislative session of Michigan, by invitation from those interested, I visited the capital, and afforded such information as had been obtained with reference to the fisheries, and at the request of the chairman of the house committee drew up a bill for the appointment of commissioners of fisheries for the State. During the session an appropriation of \$15,000 was made to defray expenses of propagating food-fishes in order to increase their numbers.

An attempt was made to interest all the States bordering on the lakes in the matter of protecting the fisheries, most of them having had the subject presented in some form previously. Letters addressed to the Governors were referred to the proper committees in the legislatures. In Ohio and Indiana the question came up in one form or another during the winter session. Illinois, though possessing a small extent of lake-coast, and having a large interest in the fish-sales of the Chicago market, has not yet taken the matter into special consideration.

The fish-dealers of the lakes were addressed, either in person or by letter, and as full statistics of the catch of 1872 obtained as possible, in order that the importance of the interest might be better understood.

2.—ACKNOWLEDGMENTS OF ASSISTANCE RENDERED.

I desire to refer to Mr. William D. Palmer, of Chicago, and Capt. Samuel Clement, of Waukegan, Ill.; Capt. E. Butlin and Mr. William Wright, of the Goodrich steamer-line; Dr. I. A. Lapham, of Milwaukee, and Mr. H. F. Dousman, of Waterville, Wis.; Mr. George Clark, of Ecorse, Mr. J. P. Clark, of Detroit, and Mr. N. W. Clark, of Clarkston, Mich., for various assistances and traveling-passes, materially lessening the expenses of the work; to Mr. E. W. Blatchford, of Chicago, Ill., for the use of instruments for deep-sea work and a complete set of nets; to Capt. David Evans and his officers, of the revenue-marine service, for their cordial assistance during the dredging-trip; to Mr. J. L. Ingalls, of Waukegan, Ill., for valuable aid in obtaining information through a long extent of shore that would otherwise have required a personal visit; and to many others who afforded information and support to this work.

In the following pages will be found the statistics of the catch of one year, conclusions with reference to the decrease of the food-fishes, the methods to be adopted for their restoration, the economical and natural

history of the more important species, and the general results of the work of the past two years.

B—GENERAL CONSIDERATIONS ON THE LAKE-FISHERIES.

3.—INVESTMENT IN THE FISHERIES.

The fisheries of the lakes are an industrial interest of large extent and considerable commercial value, of which little is known except among those directly interested.

Back from the lakes the very prevalent idea is that fishing is an unprofitable employment for an irregular class of men who eke out a meager subsistence from year to year by this pursuit. Though the risks and uncertainties of this vocation make the yearly income very variable, the investments of fishermen in their stocks are quite respectable sums, and compare favorably with the farming-communities, being all the way from three hundred to twenty thousand dollars, their sales reaching in some instances as high as \$7,000 from their own nets. This refers to those men only who actually superintend their own fisheries. A few dealers who furnish the nets on shares sell five or six times as much in a year. Nor is there any truth in the aspersion on the class of men, who are industrious, hard-working citizens, and, considering the hardships and exposures incident to their calling, singularly free from the habit of hard drinking.

The fishing-stocks are necessarily a less stable investment than farming-lands, liable to frequent loss and injury, and as the success of a fishing-season depends much on the character of the weather, there is of course uncertainty in the yearly income.

The same as in other vocations, the alternation of abundance and scarcity does not develop the provident faculty that accumulates property, for though as a class not given to dissipation, they spend their money freely for comfort and good living when the fishing is prosperous. In spite of all these unfavorable conditions many attain comfortable circumstances.

The investment of fishermen and net-owners by itself is not inconsiderable. Under your instructions last year I visited nearly all the fishing-ports on Lake Michigan, and made an accurate count of the fishing-stocks owned and used on the lake.

In the following pages are given the statistics of permanent investment, of the number of men employed, and their wages, for the year 1871.

Investment in fishing-stocks on Lake Michigan in 1871.

241 pound-nets, average value \$500.....	\$140,500
103 gill-nets, "heavy-rigs," average value \$725.....	73,950
545 gill-nets, "light-rigs," average value \$225.....	78,300
92 boats, average value \$500.....	49,000
249 Mackinaw boats, average value \$100.....	34,800

143 pound-net boats, average value \$50.....	\$7, 150
100 anchor-boats, average value \$25.....	2, 500
4 steam fishing-boats, average value \$1,200.....	7, 200
1 schooner.....	3, 000
500 shanties, average value \$50.....	25, 000
100 ice-houses, average value \$100.....	10, 000
Total of fishing investment.....	\$31, 400

The current working capital employed in the fisheries, omitting wages, and including packages, inspection, salt, ice, freightage, and repairs, is a large sum of money, probably as much as \$150,000.

The number of men employed by the nets of each kind is very uniform.

For three pound-nets, a crew of five men is necessary, while where but one or two are employed, at least four men are required.

The "heavy-rig" gill-net stocks, working a large boat, and four and five gangs of nets, with from twenty-five to thirty-six nets to the gang, have five, or six men to the crew.

The "light-rigs," with a 22-foot "Mackinaw boat," and three or four gangs of from eight to twenty nets, have a crew of two or three men.

It will be observed that the boat is the unit of a fishing-stock. It is so considered among gill-netters, as they speak of so many boats "light-rig," or "heavy-rig," in a locality. It has not been adopted among the pound-net men, though it would apply nearly as well.

Though the number of boats represents the number of separate establishments, they do not, however, correctly number the proprietors. There are net-owners on the lakes who have from twenty to thirty thousand dollars invested in nets, and who furnish nets and full outfit to as many as forty establishments, in the "light-rig" gill-net fisheries: the fishermen, in the parlance of the lakes, "filling" the furnished half-barrels on shares.

On Lake Erie there are net-owners who employ a sufficient number of men to run forty pound-nets, paying wages and receiving all the fish. On the other hand, the majority of establishments, managed by the owners, are partnership concerns.

Out of about two thousand men engaged in the fisheries of Lake Michigan, but a few more than half are men receiving wages, and some of these are the minor sons of the proprietors.

The time for which the men are hired varies in different localities. In a large region of the lake-fishing, the season lasts from seven to eight months.

As early as the month of April, before navigation has opened, the fishing-boats are plying daily from their harbors to the fishing-grounds, often finding the run of fish plentiful at this season. In 1871, many of the fishermen began the season before the middle of March. In the fall they prolong the work late into November and even December, and in very open winters, from a few ports, nets have been set, within

three or four miles of the shore, every month in the winter, continuing the fishing throughout the year.

Where fishing through the ice is carried on, men are employed for winter work.

On Lake Michigan, in 1871, the summer fishing in the vicinity of Waukegan, Ill., afforded employment to about forty-four men during three months of the year; the spring and fall fisheries of the lake employed about eleven hundred and eighty men during five months; the year fishing employed about seven hundred and sixty-five during about seven months; in all, about one thousand nine hundred and eighty-nine men, of whom only about nine hundred men received wages. The total outlay was about \$180,000 in the season.

4.—THE EXTENT OF THE LAKE-FISHERIES.

No attempt at obtaining any very complete statistics of the product of the lake-fisheries has hitherto been made, and in the census reports of the United States few and fragmentary figures of this large interest have been given. A complete exhibit, or one as complete as may be made of most of the market commodities, would be difficult to obtain, as a large amount of fish is used in the local demand in the vicinity of the fisheries, which is sold directly by the fishermen to residents, peddlers, and traders on steamers, and no account of it is kept. The tables of steamers and vessels are also supplied in this way. There are also a large number of small dealers, who keep no books, receiving and selling fresh fish in lake cities. So that of a large amount of the fish caught no record is made; and of the quantities taken reliable statistics of not more than about seventy per cent. can be obtained.

The handling of the lake-fish on the market employs quite an amount of capital. Large warehouses are necessary for storage and the assorting and inspection of the fish, and are to be found in all of the larger cities. In the salt-fish trade, great quantities of salt come a second time into demand, for use in repacking.

Of late years a process of freezing has been resorted to for the shipment of fresh fish. This process has been patented, and the right sold in all the important cities on the lakes. Large freezing and preserving houses have been erected, and hundreds of tons of fish are frozen while fresh, and shipped in this condition to New York, Washington, Cincinnati, Saint Louis, Omaha, and intervening cities.

Many of the dealers employ small steamers in visiting the fisheries, and gathering in the fish that are salted on the shore.

For the purpose of showing the extent of the fisheries, and their value as a commercial and food resource, we have attempted, since the close of the fishing-season, to obtain an exhibit of the catch of the year, as complete as possible, for the whole extent of the lakes.

Though most of the dealers responded cheerfully to the application for figures from their books, a few failed to comply, and the tables are

in consequence deficient of some large quantities handled by dealers in such places as Toledo, Ohio, and Detroit, Mich., and in a few points of lesser importance. The sales in Cleveland are large enough to compare with those of Sandusky, Buffalo, and Chicago, but the amounts obtained from that city, though cheerfully afforded by all who had them at command, are those only from original points, directly from the net-owners, and the gross sales were not in our possession. By far the larger proportion of the catch of Lake Huron and Lake Superior finds its way into the markets of which we have afforded statistics, and the deficiency of the sum-total of their catch will be what has been shipped into the interior of the State. From these causes probably fifteen per cent. of the quantities put upon the market are not in the tables, while the local consumption before referred to, would add still more to the totals; in all, perhaps, twenty-five per cent.

5.—STATISTICS FOR THE YEAR 1872.

The fishes in the tables are classified according to the system adopted at Sandusky, Toledo, and Cleveland. This system includes under "hard fish" the wall-eyed pike, called pickerel on Lake Erie, *Stizostedion americana* Cuv. and Val.; the black-bass, *Micropterus nigricans* Cuv.; and the *Micropterus salmoides* (Lac.) Gill, mss.; the lake-pike, *Esox lucius* Lin.; the muskellunge, *Esox nobilior* Thomps.; the salmon-trout, *Salmo namaycush* Penn.; and the white-fish, *Coregonus albus* Les. The skinned cat-fishes, selling for the highest prices in the market, are also included. Under the head of "soft fish" are comprised the sauger, *Stizostedion grisea* DeKay; the white-bass, *Roccus chrysops* (Raf.) Gill; the suckers, *Catostomus communis* Les.; *C. aureolus* Les., *C. melanops* Raf., and the carp, *Carpodes cyprinus* Les. "Mixed fish" includes both kinds.

* Statistics of the number of pounds of lake-fishes received by first handlers for the year 1872.

Place.	Hard fish.	Mixed fish.	Soft fish.	Lake herring.	Sturgeon.	Salt fish.
Rochester, N. Y.	11,725	78,000	.....	.....	.....	.....
Buffalo, N. Y.	1,471,028	.....	656,530	.....	.....	3,008,000
Erie, Pa.	193,446	.....	.....	.....	.....	.....
Conneaut, Ohio.	187,498	.....	.....	.....	.....	.....
Ashtabula, Ohio.	27,820	.....	.....	.....	.....	.....
Cleveland, Ohio.	1,016,843	.....	54,460	96,297	.....	3,750,000
Sandusky, Ohio.	1,646,315	394,405	501,046	1,580,249	730,500	.....
Put-in-Bay, Ohio.	85,000	.....	12,000	146,600	.....	.....
Huron, Ohio.	197,891	.....	76,603	913,223	.....	.....
Toledo, Ohio.	1,263,695	.....	983,505	1,080,400	.....	.....
Detroit, Mich.	2,346,100	.....	160,880	21,000	.....	1,800,000
Mackinaw, Mich.	471,468	.....	25,000	135,240	.....	.....
Green Bay, Wis. ....	.....	662,000	.....	.....	.....	.....
Milwaukee, Wis. ....	.....	.....	.....	.....	.....	653,300
Chicago, Ill.	4,712,198	18,800	17,784	167,673	25,147	2,519,500
In the hulls of vessels frozen in on Lake Superior. ....	.....	.....	.....	.....	.....	276,000
Total.	13,640,927	1,133,205	2,387,608	4,122,621	745,647	10,198,800

* All quantities exchanged between the places named, after being recorded for their original market, are deducted from the receipts of the subsequent one.

† The figures opposite Sandusky include both the fresh and salt fish.

‡ Incomplete.

§ Obtained only through newspaper sources.

The sum-total of this incomplete record is 32,250,000 pounds of fish, with a value of \$1,600,000.

The two ports handling the largest amount of fish are Chicago, Ill., and Buffalo, N. Y. Their relative figures are shown below:

Place.	Hard fish.	Mixed fish.	Soft fish.	Lake herring.	Sturgeon.	Salt fish.	Total.	Value.
Buffalo, N. Y.	2,428,750	.....	937,350	.....	.....	3,008,000	6,374,100	\$333,625 08
Chicago, Ill.	4,712,198	18,800	17,784	167,673	25,147	2,519,500	7,461,104	414,717 50

Sandusky, Ohio, Detroit, Mich., and Cleveland, Ohio, would also show large figures in their gross sales. The table of statistics, as it shows in most cases only the original quantities received from fishermen and markets not recorded, of course does not exhibit the entire business of the different places.

6.—CHARACTER OF THE FISHING IN DIFFERENT LOCALITIES.

The seasons and methods of fishing vary very much in different localities. Slight differences in market demands at various points influence the capture of certain species. Difference in depth of shore-waters controls the range of some kinds of fishes. The season varies somewhat in different parts of the lakes, while the number of nets and men to the boat, as well as the size of the boats, is dependent on numerous conditions.

6.—IN LAKE SUPERIOR.

In Lake Superior, within the bays and among the islands, the pound-nets are used. The bold shores of the greater part of the lake will always prevent the use of these nets to any very injurious extent; though, from the local habit of the white-fish, some of the best localities may become depopulated.

The principal fisheries are in the region of the Apostle Islands and at White-Fish Point. In both places pound-nets are in use, but the gill-nets are, thus far, used in greater number. The other fishing-localities of consequence this season were at Grand Island, Marquette, islands to the east of Keweenaw Point, and Superior City. The Canadian fisheries, except those of Michipicoten Island, are principally under the Hudson Bay Company's control, at Michipicoten River, the Pic, and at St. Ignace Island, and are all gill-net fisheries.

7.—IN LAKE MICHIGAN.

As the fisheries of Lake Michigan were worked up in detail in the year 1871, a description of the character of the fishing in different localities may be valuable for the light it may afford as to the necessity of discrimination in legislating for different regions.

Beginning at South Chicago, near the head of the lake, there were ten pound-nets, distributed along about eleven miles of coast, lying three miles to the north and eight miles to the south of the Calumet River. Unlike pound-net men in other portions of the lake, they here seek to catch every variety of fish, finding sale to the peddlers of everything but the dog-fish, *Amia calva* Lin.

At Chicago there were six boats fishing with trot-lines off the mouth of the river; their catch being almost entirely the perch, *Perca flavescens*. One man is employed during the season at Milwaukee catching bait, shipping tubs full of minnows daily.

There has been no net-fishing here for years, the few experiments made proving failures. It is quite possible, now the filthy current of the river no longer flows into the lake, that there may be some success with nets.

At Evanston, the pound-net fishing was of very much the same character as at Calumet. At both points they have a spring and fall season, taking out the nets in hot weather, when the fish leave the shoal waters.

From Lake Forest and Waukegan to the Wisconsin line were twenty-seven pound-nets, fishing for both the fresh and salt fish markets. In this region comparatively few fishes are taken other than the white-fish. One proprietor has built a smoke-house, preparing and boxing the smaller white-fishes for the Chicago market, where they are sold as smoked herring. If there were no other objection to the capture of the small white-fish, than their useless destruction, this could be easily remedied by disposing of them in this way, as they find a quick and profitable sale, the demand being far in excess of the supply.

The season here is different from most other parts of the lake. Instead of a spring and fall season, with an interim of two months, in which the nets are taken out, the fishing, beginning late in May, lasts until the first week in September; the fisheries having their greatest run during the months in which the least fishing is done at most points on the lake.

It will be observed that in Illinois's share of the lake-shore no fishing is done, save with pound-nets. It is not likely that gill-net fishing would be undertaken here if pound-nets were prohibited, as it would be too hazardous of life and property. Gill-net fishing is adapted only to a coast with good boat-harbors, or at any rate favorable lees, as in high winds, driving heavy seas on the shore, there is great difficulty in landing, and often when there is not sufficient sea outside to prevent taking up the nets, it is very difficult to launch a boat that would experience no inconvenience when once fairly out from shore; so that nets from a shore like this often remain out for days, while a few miles off from a harbor the boats run out and take up every day. Frequently they are caught in a gale when outside, and are obliged to run for harbors twenty or thirty miles to the north or south because of the danger they would incur in beaching. The large number of deserted fish

ing-shanties along the beach, on the east shore of the lake, attests the impracticability of gill-net fishing from a lee shore.

In this extent of shore there is no spawning-ground known for either the trout or the white-fish, though the fishing is not carried on sufficiently late in the season to find the species named upon their spawning beds.

From Kenosha to Sheboygan are some thirty boats, working the "large gill-net rigs," having from five to six gangs to the boat, and from twenty to thirty nets to the gang, making the string of nets a mile or more in length, and requiring a crew of five men. They run out from shore from eight to twenty miles, according to the range of the white-fish and trout at different seasons. The boats used in this region are principally what are called the "square stern."

At Kenosha five of the boats are "Norwegians," and one a steamer, remodeled from a large "Huron boat."

At Milwaukee, for a time, the most of the boats were the sloop-rigged "Norwegians," afterwards abandoned, and the square stern adopted; and during the past year small steamers were substituted for some of these.

On this line of coast, and farther north, where steamers land daily, the bulk of the catch is shipped fresh, in ice-boxes, to the Chicago dealers.

In the northern half of this extent of shore there are some twenty-four pound-nets, for the most part packing their fish, as the steamers do not land at the points where they are located.

The catch throughout this region is almost wholly white-fish and trout, the gill-nets in the spring and fall taking a quantity of "lawyers," *Lota maculosa*, that are thrown away as useless, except where a small local demand is supplied in the towns. The spawning-grounds begin to the southward of Racine, Wis., and are found northward along the whole extent of shore.

At Two Rivers, and north to the islands, the boats are "Mackinaws," working the lighter rigs of gill-nets, with from eight to twenty nets to the gang, and three or four gangs to the boat, with a crew of from two to three men, and running out from shore seldom more than seven or eight miles.

This is the character of the fishing with gill-nets—after excepting the Door Islands, where a few steamers and large sail-boats are used—for Green Bay and its islands, the north shore, the Beaver, Fox, and Manitowish groups of islands, and the east shore of the lake, as far south as Manistee. The gill-net catch, throughout this line of coast, is little else than white-fish and trout, except in Grand Traverse Bay, where the black-fish, *Coregonus nigripinnis* Gill, (Mss.) is found abundant.

At Point aux Barques and Seul Choix Point, a large type of the *Coregonus albus* is taken, feeding principally on the *Mysidæ*. Fishes of eight, ten, and twelve pounds are common in every lift, while as high

as eighteen pounds are claimed to be occasionally taken. Gill-nets with a mesh of five inches are in common use in this vicinity.

The pound-nets, from the head of Green Bay as far north as Peshigo, take little else that are made use of but lake-herring. A few pickerel and wall-eyed pike—dories, as they are called here—are packed, while sturgeon are thrown away.

From Peshtigo, north, the catch is principally white-fish, with a few trout, pike, and sturgeon. In this region of shoal waters these nets are frequently set four and five miles from shore, some of them in forty-five feet of water.

The west shore of Green Bay is the great pound-net region of the lake, about ninety pound-nets having been in use the past season.

Green Bay is the home of the wall-eyed pike, or dory, *Stizostedion americana*—as they are here in larger numbers than in any other part of the lake.

The sturgeon are taken in great abundance in this region, and are almost universally destroyed. They come into the nets in great numbers in the early fall, and are pulled into the boats with the gaff-hook, and thrown upon the offal-heap.

A pound-net, one long leader with a pound at each end, was set at about six miles from the land, off Big Bay de Noquet, on a 36-foot shoal. The proprietors owned a small schooner, which they kept anchored alongside. They did remarkably well, catching a large grade of fish.

From Seul Choix Point, eastward to Mackinaw, and southward to Little Traverse, Michigan, the pound-nets are used with success. In Grand Traverse Bay, and at Leland, they succeed during the fall season; but from this point south, along the east shore of the lake, pound-net fishing has proved an entire failure and has been abandoned.

From Manistee, south to Michigan City, the larger gill-net rigs again come into use, with four and five men to the boat. The fishing is done from seven to ten miles from the shore, until, near Saint Joseph, the "run out" reaches from twenty to twenty-five miles. There is no spawning-ground from Saint Joseph southward, and consequently no late fall fishing.

From Manistee, south, the bulk of the fish caught are packed in ice and shipped fresh to Chicago, and a few to the interior of Michigan.

In the winter season, after the surface of the water in Green Bay has frozen to a sufficient thickness, the fishing is again begun to a limited extent. Holes are cut through the ice, with chisels made for the purpose, and baited hooks are lowered, in hopes of finding a school of trout in the locality. If unsuccessful, other holes are cut at a distance apart, until the fish are found, when they are hauled out as fast as they bite, a fisherman taking from twenty-five to seventy-five a day, weighing from one hundred to three hundred and fifty pounds, which are hauled home at night on a hand-sled.

Gill-nets are set beneath the ice, by cutting holes a rod or more apart, and sliding a line along from one hole to another, until the desired distance is attained, when a gang of nets is attached and drawn through.

The fisherman has a shanty, placed on runners, with a section of the floor removed, and with a good fire in the stove, within a few feet of him, he lifts his nets and removes the fish, entirely protected from the weather.

During the past winter, a pound-net was allowed to freeze into the ice, and a shanty built over the crib, or pot, so that it could be lifted through the opening, daily, without inconvenience.

8.—IN LAKE HURON.

On the greater part of the American side of the Lake Huron shores the fishing is done with gill-nets. There are a number of pound-nets in use in Saginaw and Thunder Bays, and a few at other localities. Seine-fishing for the wall-eyed pike is done on a large scale near Bay City, Mich., on Saginaw Bay.

Except at the northern end of the lake, the large Huron boat is used in the gill-net fishing, and gangs of from thirty to sixty nets are set at from eight to twenty-five miles from shore. At the northern end of the lake the Mackinaw boat is used, with fewer nets.

The fisheries of Saginaw Bay are somewhat unique in character. Gill-nets are set in the ordinary season from the shores near the entrance of the bay. Pound-nets are numerous on both shores up to the mouth of the river; as many as two hundred have been in use at once.

Close to the mouth of the river are the seining-grounds. Four or five 80-rod seines are in use on each side. On the one side where the current sweeps shoreward they are made of coarse twine and have heavily leaded lines, and are strong enough to carry ashore slabs, logs, and everything found in their way. The seine is laid out up-stream, and the current sweeps it on the shore below, when lines are made fast to the bag and it is drawn out by means of a 2-horse windlass. On the opposite shore, where the current sweeps out, there is the necessity for lighter seines and heavy leads, as there is a tendency to lift the lead-line from the bottom and allow the fish to escape underneath; a difficulty that is said to have never been entirely obviated.

As soon as the ice leaves the river in the spring, the seines are swept over the grounds, and usually immense quantities of wall-eyed pike, *Stizostedion americana*, are taken; several tons are sometimes secured in a single haul, and the result of the seasons' fishing is often two thousand packages. The fishing only lasts about three weeks.

The pound-nets take a variety of species. The wall-eyed pike is the more numerous species, and the white-fish next. The fall fishing is said to be the more important for this class of nets.

The winter fishing is very extensive. Holes are cut through the ice and gill-nets are set, pound-nets are allowed to freeze in, keeping only the

surface of the crib open. Wooden "lure-fish" are used attracting the Mackinaw trout to the holes, where they are taken with the spear. Temporary houses are built upon the ice, until quite a village grows up, and traders take out small stocks of goods and establish stores.

There is the most evident reduction of the quantities of fish taken throughout the shores of this lake within a short term of years.

9.—IN SAINT CLAIR AND DETROIT RIVERS.

At the head of Saint Clair River, large fisheries were in operation several years ago, but the enterprise has gradually diminished, as the fish became fewer in numbers, until now three or four fisheries have the fishing-privileges almost entirely to themselves.

Between the mouth of Detroit River and the city are a number of fisheries, employing a large number of men in the fall of the year, and proving as lucrative to their proprietors as any fisheries on the lakes.

The "Ponds" of Detroit River.

These fisheries, known as ponds, are among the most extensive establishments of the lake. Large numbers of white-fish are kept alive in them, from the fall of the year to late in the winter, when they are taken out, and sold in the market at good prices. The best ponds are situated at islands in the middle of the river, where there is an ample circulation of water, keeping the fish in vigorous, healthy condition for months.

The pond is merely an inclosure in the river, made by driving piles close together, and afterward sheathing the inside with planks, leaving joints of three-quarters of an inch width, to allow the free circulation of water through the pond. At one end of the pond a gate is put in, hinged at the bottom of the river to a mud-sill, and the upper portion, floating at an angle of about 45°, projects a foot or more above the surface, closing the entrance to the pond. By pushing the gate beneath the surface, with a pole, it is opened to the extent of one, two, three, or more feet, according to the depth the top of the gate is pushed down.

The accompanying plate represents one of the best arranged and conducted fisheries on Detroit River. The buildings for the men, the net-house, and the store-house, with the windlass-sheds, are all in view. It will be seen that the fishing is carried on by sweeping a seine in front of the pond, that is drawn in by horse-power. When the brails come on shore the men haul in the seine until the bag is reached, when the leads are thrown over the top of the gate, which is then pushed down, leaving an open space at the surface, of two feet, through which the fish are emptied into the pond without being touched by the hand, or taken above water.

At this fishery the seines in use are about one hundred rods long. A gang of thirty men are employed from September to the middle of November, working in two relays, night and day, and averaging about

one sweep of the seine every hour. In each pond from twenty-five to forty thousand white-fishes, and a number of other species, are penned up every season.

There are nine ponds belonging to American proprietors, and seven belonging to Canadians.

10.—IN LAKE ERIE.

Lake Erie produces large quantities of food-fishes of several varieties. The wall-eyed pike—pickerel, as it is incorrectly named in the region—the blackbass, the white-fish, the lake-herring, the salmon-trout, and the sturgeon, are all staple fishes; while, besides these just named, a number of species of inferior food-fishes are shipped from the western portion of the lake, under the general class of "soft fish."

The large quantities of fish that have been taken from the western part of this lake indicates the fact that shallow waters are more productive of numbers than the deeper regions. And this is not only established by comparison with the other lakes, but is confirmed by the fact that the eastern, deeper, and larger portion of Lake Erie does not produce anything near the quantities.

The western end, from near Huron, Ohio, is shoal, full of islands, and a very great number of pound-nets are in use, the fish being carried to the adjacent towns; Sandusky receiving the largest share. In the other part of the lake gill-nets are principally used.

11.—IN LAKE ONTARIO.

From the information received from Lake Ontario, it is evident that the fisheries are more reduced than in either of the other lakes. There are few fishermen engaged on the American side, and but a comparatively small supply of fish afforded.

12.—BOATS USED IN THE FISHERIES.

The boats used in the fisheries are of several kinds and constructed on very different models. The "Mackinaw," the "Huron," or "square stern," the "Norwegian," and the "pound-boat," are the ordinary boats.

The famous "Mackinaw" of the lakes has bow and stern sharp, a great deal of sheer, the greatest beam forward of amidships and tapers with little curve to the stern. She is either schooner-rig, or with a lug-sail forward, is fairly fast, the greatest surf-boat known, and with an experienced boatman will ride out any storm, or, if necessary, beach with greater safety than any other boat. She is comparatively dry, and her sharp stern prevents the shipment of water aft, when running with the sea. They have been longer and more extensively used on the upper lakes than any other boats, and with less loss of life or accident. The objection to the more general use of the Mackinaw is that her narrowness aft affords too little room for stowage. They are employed entirely with the light-rig gill-net stocks, and are usually from twenty-two to twenty-six feet in length. Lake Superior, the northern half of Lake

Michigan, and a large portion of Lake Huron, are the regions where they are in general use.

The "Huron" or "square stern" is the boat in most general favor where the large gill-net rigs are employed. It is the ordinary model of a schooner-rigged sail-boat, with less sheer than the Mackinaw, but with plenty of room for nets, fish, or half-barrels. The better models are faster than the Mackinaws. They are generally from thirty to forty feet in length; in most of the regions where they are employed the fishing is done much farther from shore than in the "light-rig" localities. An inquiry into the history of loss of life and accidents among the fishermen of Lake Michigan indicates that these boats had suffered the most, partly, no doubt, because of their longer runs out from shore.

The "Norwegian" is a huge, unwieldy thing, with flaring bows, great sheer, high sides, and is sloop-rigged. She is absolutely dry in all weathers, and though perfectly safe, and with ample room, she is only used by the Scandinavian fishermen, most other fishermen objecting to her slowness and the great labor of rowing in time of a calm. These boats are in use in but very few localities. They are from thirty-five to forty feet in length.

The pound-boats in use in the western end of Lake Erie are very well adapted to the purposes for which they are employed. They are flat-bottomed, wide-beam, very simply-made boats, with a large center board, and carrying two very tall spars, and a wide spread of canvas. They are quite fast before the wind, and very roomy. They are used in transporting the fish from the nets to the warehouses and freezing houses. They are usually forty feet in length.

The ordinary pound-net boat is flat-bottomed, is made from rough boards, and managed with oars only.

The small steamers now used in a few localities are built much after the model of the small river-tugs, but with no upper works, and with wide hatchways extending along half the length of the deck. They are used only with the heavy gill-net rigs.

D—THE DECREASE OF THE FOOD-FISHES.

The special investigation in reference to the decrease of the food-fishes was prosecuted among the fisheries of Lake Michigan. The impression prevails that there is an alarming diminution of the food-fishes of the lakes. This is the ordinary feeling among dealers, a majority of the fishermen, and the people generally.

The supply of fish for the Chicago dealers has steadily increased with the demand, for a number of years, until this season. This is their testimony, and is evidenced by statistics of inspection, kept on file among the city's papers since 1854. This is to be attributed to the fact that the territory fished over has increased in this lake, and that, wherever the lines of steamers and railroads are extended, fisheries are established at new points. From Lake Superior, too, since regular communication

has been opened, a large amount of fish has been shipped to the Chicago market.

13.—THE EVIDENCES OF THE DECREASE.

Statistics to prove decrease are hard to find, as but few records are kept in the localities where the fish are caught; when they have been preserved they show an evident diminution.

The summing up of shipments from the pier at Two Rivers, Wis., affords the following:

	1867.	Pounds.
Fresh fish.....		332,000
Salt fish, 6,351 packages.....		635,100
	1868.	
Fresh fish.....		153,950
Salt fish, 4,679 packages.....		467,900
	1869.	
Fresh fish.....		185,350
Salt fish, 3,661 packages.....		366,100
	1870.	
Fresh fish.....		203,100
Salt fish, 2,811 packages.....		281,100

At this port the decrease has been fifty per cent. in four years.

A firm in Mackinaw, receiving yearly a large amount of fish, by reference to their books gave the following figures, as totals of shipment: In 1869, 17,000 packages, of one hundred pounds each; in 1870, 13,000 packages; and though they had not carried out their records for 1871, said they would fall very much short of the figures for 1870.

The best evidence of decrease in the numbers of the fish is the testimony as to the few nets used formerly, with the same or greater success than is had now with about three times as many. Formerly, too, many of the nets were made of coarse cotton, not as well adapted for entangling a fish as fine linen twine; the mesh used was one-fourth of an inch larger, and, it is claimed, the fishing was done much nearer shore.

More labor, more expense, and more skill in the construction and use of nets are required now than formerly, and for the capture of a less quantity of fish.

The white-fishes are smaller now than formerly; in early times it is said that on an average fifty gill-net fishes would make a half-barrel; now it requires about eighty or ninety.

Of the staple fishes taken in the lakes—white-fish, *Coregonus albus*; trout, *Salmo namaycush*; herring, *Coregonus clupeiformis*—there has been an evident decrease of the white-fish and the trout.

Occasionally, after several years of small encouragement to the fisheries, at some point hopes are revived by a heavy run of fish upon the coast. The investigation for decrease cannot be understood from the quantities of fish taken at isolated places; the fishes are not by any means distributed evenly throughout the lake, but range in large colonies

and run near the shore at different points, while the majority of localities may be entirely destitute of fish.

14.—WHEN THE DECREASE BEGAN.

The oldest fishermen I have met claim from twenty-five to twenty-eight years' fishing in the lake. They assert the fish to have been abundant, running in near shore, and that hauls of large quantities were made with the seine.

The custom in many places was to employ the Indians to watch the shore for a near run of fish, and when discovered draw the seine around them. Immense quantities were taken in this way.

There are no recorded statistics that show a reliable calculation of dates, but the testimony of fishermen, dependent on their recollection of their purchases of nets and changes in their modes of fishing, places the beginning of a marked decrease within about ten years.

15.—THE AMOUNT OF DECREASE.

The amount of decrease, in the absence of statistics of capture, cannot be decided very definitely. The records of shipments from Two Rivers, on a previous page, show a decrease of fifty per cent. in four years.

The reduction in the number of boats at different localities, perhaps indicates to some extent the amount of decrease in the fish.

In 1858 there are said to have been thirty-three gill-net boats, fishing from Milwaukee, Wis. In 1871 there were but fourteen.

Between Kenosha, Wis., and Chicago, Ill., the pound-nets have diminished from thirty-six in 1869, to twenty-seven in 1871.

At White-Fish Bay, Door County, Wisconsin, formerly an extensive fishing-ground, there are now but three pound-nets.

A profitable fishery at North Bay is now entirely abandoned. The pound-net fishermen at Two Rivers complained of the scarcity of white-fish, and one asserted that a law prohibiting pound-net fishing would not be a very serious loss, in consideration of the poor success they had had for a few years. Compare this condition of things with the record of 1864, in the report of Hon. Theodore Wendell to the Michigan legislature, in which, from four pounds, 2,800 half-barrels of fish were taken in White-Fish Bay, Wis., and with a few more nets a firm of fishermen, Sage & Douglas, took 4,000 half-barrels in the same region. The pound-net men generally acknowledge the decrease of the fish in their own localities, and attribute it to various causes.

At Ausable, Mich., on Lake Huron, there are said to have been forty-two boats in 1865; while at present there are but six.

The estimate of decrease, within safe calculations, is all of fifty per cent., which, in a period of ten or twelve years, is sufficiently large to be alarming.

16.—THE CAUSE OF THE DECREASE.

If the take of fish, by nets of all kinds, is greater than the natural

annual increase, the numbers must of course diminish, and over-fishing is to be considered in investigating the causes of decrease. Still, it is very evident that much more wholesale causes than merely the number of nets in use exist in the lakes, the principal one being the capture in large numbers of small fishes by the pound-nets.

The taking of full-grown, mature fishes, so long as all are preserved and used for food, cannot be questioned as a legitimate and rightful occupation. The capture of half-grown, immature fishes is less legitimate, not only from the fact that the number is diminished by the amount taken, but that the supply of full-grown fish in the waters throughout a term of years, being no greater than the demand, it is evident that if this demand is filled from half-grown individuals their numbers will diminish from year to year at an accelerating rate. And this accelerating ratio of loss is seen to be multiplied many times, when we take into consideration the fact that the supply is barely kept up if only those fishes are taken which are sufficiently matured to have spawned once or twice, while the destruction of fishes, too young to have spawned, must reduce the natural increase by perhaps hundreds in the death of each one.

If every fish that had passed the precarious embryonic stages and developed into a thrifty swimmer of four or five ounces, had been allowed to mature, and to spawn once or twice before it was taken out of the water, the supply of white-fish would not have diminished to any great extent.

The capture of immature fishes is, without doubt, the principal cause of a decrease.

The taking of fish in too large quantities to allow of handling and preservation, the destruction of fishes too small for use, or of others because they are not in a special line of fishing followed by certain fishermen, or the capture, when used, of those not old enough to spawn, are all entirely wrong and destructive to the fishing-interests.

(16 a.) *The pound-nets.*—In observing the lifts of white-fish taken from the pound-nets during the spring and summer seasons of fishing, along the west shore, they were estimated to contain from one-twentieth to one-sixth of small fishes, that, when prepared for salting, entrails and heads removed, would weigh less than eight ounces. These, among fishermen supplying the peddlers, are all made use of. A few fishermen prepare them by a slight salting and smoking, and sell them in boxes, as smoked herring, but the majority are compelled to bury them, as useless, as they are smaller than any grade recognized in the salt-fish market.

The inspection-regulations of the Chicago market, that are accepted throughout Lake Michigan, provide for three grades of white-fish, with reference to size. The inspection is intrusted to the judgment of the inspectors without any very exact stipulations as to dimensions or weight of the different grades.

The standard of inspection, of the best inspectors, which is also approved by most of the dealers, though not establishing the grade by weight, virtually makes the minimum weight of a No. 1 white-fish about one and one-quarter pounds; a No. 2 fish, about three-quarters of a pound; and the weight of a No. 3 fish, from three-quarters of a pound to less; this is after the head and entrails are removed.

On counting pound-net fish, as they were repacked by dealers, fishermen's uninspected packages, one hundred pounds, were found to contain from one hundred to one hundred and eighty fishes; in the latter case the fishes averaging less than nine ounces. Numbers of small fishes, weighing from five to six ounces, are found in the pound-net packages.

Certain localities, as the north shore of the lake, have a large type of fish; but of pound-net white-fish, taken in a season, throughout this lake the average would not be above the No. 2 grade in weight.

An advantage the pound-net has over the gill-net, or seine, in warm weather, is, that in a large catch of fish it is possible to take out just such a quantity at a time as can be handled, leaving the rest alive, and fresh until it is convenient to return for them.

In the gill-nets the lift must all be brought ashore at once, and what can be dressed and packed in a few hours are used, while the remainder spoil and have to be thrown away.

Pound-net fish are generally superior to gill-net fish to ship fresh, because they are always fresh when put in the ice-boxes, while those from the gill-nets may have been dead twenty-four hours or more.

(16 b.) *The gill-nets.*—The white-fish taken in the gill-nets, in Lake Michigan, will average much higher than No. 2 fish. From reference to the books of dealers in Chicago, and an extended observation of the gill-net fishing, it is evident that the entire catch of the lake would not give as low an average weight as one and one-quarter pounds. The inspection of fishermen's shipments of gill-net fish seldom affords as low a proportion of No. 1 fish as one-half.

The reasons for the larger size of the gill-net fish are in the facts referred to on another page, in reference to the habit of the immature white-fish to remain near the shore, the least depth employed for the gill-nets, being twelve or fifteen fathoms, entirely outside of the range of the smaller white-fish.

The gill-nets destroy a great many fish in time of storms, when the fishermen are not able to visit the nets for days at a time, two or three days being sufficient during the summer months for the fish to die and become tainted, when they are thrown overboard to rot on the fishing grounds, making it offensive to the white-fish and driving them away.

The gill-nets, when they are lost, destroy fish by entangling them until the floats become water-logged and sink. They have been grappled up, two years afterwards, while searching for nets recently lost, full of decayed fish. This is quite an extensive agency of destruction, as a

great many gangs of nets are lost in the lake every year by heavy storms, and many in the late fall by being left out until storms and ice prevent their recovery.

A species of fish of good size and really fair flavor is destroyed in large quantities in certain localities by the gill-nets, from the fact that there is no demand for it in the general market. This is the so-called "lawyer," the spotted burbot, *Lota maculosa*, one of the family of Gadoids, to which belong the cod, the haddock, and the ling, all well received in the market. The lawyer is rejected because of a prejudice against its appearance. The peddlers in Chicago, and the proprietors of fish-stands in Milwaukee, find no difficulty in selling it. The livers are very large, and are occasionally obtained in quantity, and regarded as a rare dish by experienced persons.

(16 c.) *Throwing offal on the fishing-grounds.*—It is the uniform testimony of all fishermen that throwing offal or dead fish in the vicinity of the fishing-grounds is offensive to the white-fish, and drives him away.

The white-fish is peculiarly cleanly in its instincts, and has an aversion for muddy or foul water of any description. Most fishermen regard their own interest sufficiently to be careful in this particular, while many careless and shiftless men injure themselves and others by dumping offal and dead fish anywhere in the lake where they find it convenient, reducing the catch of fish in the vicinity for several months. Unsalable fishes are generally thrown overboard in the vicinity of the nets.

(16 d.) *Pollution of lake-water from sawdust.*—The refuse from the saw-mills, slabs, sidings, and sawdust, is thrown into the streams in immense quantities to float out and sink in the lake. It is having a very injurious effect upon the fisheries. The water-logged slabs, tilted on the bottom, and moved by currents, tear and carry away the nets. The sawdust covers the feeding and spawning grounds of the fish, and is so obnoxious to them that in the vicinity of numerous mills, as at Muskegon, Mich., the fisheries become greatly reduced in numbers and success.

The observations of Alfred Blais, a fishery-overseer in the employ of the Canadian marine and fisheries department, discovered the salmon-ova, diseased and decaying, with particles of sawdust adhering. Its contaminating effects extend far and wide from the vicinity of the mills, as the contents of a dredge, from one hundred fathoms depth, in Grand Traverse Bay, contained numerous blackened and decaying particles of sawdust.

The gradual deposit of water-logged sawdust, an inert substance, in the water, with occasional slabs, forms nuclei for sand-bars in the mouths of the rivers, and in some of them will contribute to an injury to navigation, as it has to a considerable extent in the Menominee River of Wisconsin and Michigan.

E.—PRACTICABLE METHODS OF INCREASE.

It is a matter of great importance that means should be immediately employed to arrest further decrease in the numbers of the lake-fishes,

and an effort be made to restore them to their former numerous condition.

There are two methods that present themselves to accomplish this purpose. The more efficient one is artificial propagation; the other, necessary as an auxiliary to the first, is legislation.

17.—PROTECTIVE LEGISLATION.

The experience of the past, both in Europe and the older portions of our country, indicates the inadequacy of protective legislation in preventing the decrease and extermination of the food-fishes.

In the compilation of the laws relating to the protection of fisheries in Massachusetts, published in the sixth annual report of the commissioners of inland fisheries of that State, there were three hundred and fifty-nine acts, passed by the legislature of the State between the years 1623 and 1857, involving directly the protection of the food-fishes. In 1857 the first provision for propagation was made. Until this time, though the law had the influence to retard the decrease, it had not prevented it, and the salmon were exterminated, while the shad were reduced in numbers, until the fishing was unprofitable, and their price in the market very high.

The propagation of the shad restored their numbers in a few years until they were more abundant than for fifty years previously in the Connecticut River, where the experiment was made.

The alewives were rapidly renewed in numbers, and the effort is now being made to restore the salmon.

The fish-protection laws of Great Britain date back before the Middle Ages, while the restoration of numbers in the salmon is owing to fish-propagation by the artificial methods within the period of a few years.

This has been the general experience. The effect of the law, when most efficient, has been merely preservative, while that of propagation is restorative.

The greatest necessity in the way of legislation in the lake-region is the protection of the immature fishes from capture and destruction, and this should be the principal aim of laws regulating the fisheries.

To accomplish this, a great many have advocated the entire prohibition of the use of pound-nets, believing it to be the simplest effective way of disposing of the matter. It must be understood, however, that it would work ruin to every pound-net fisherman. The nets and boats are entirely useless for any other purpose than pound-net fishing, and the fisherman's entire property, with comparatively few exceptions, is invested in his fishing-stock, occasionally reaching a figure as high as four or five thousand dollars, and rarely as low an amount as four hundred dollars. Besides, though it would arrest the decrease, it would reduce the product of the fisheries for several years, because of the great decrease in the number of nets, and the whole fishing-interests of the lakes in the market would be embarrassed in consequence.

The possibility of handling the fishes over as they are dipped out of the "pot" or "crib," and sorting small fishes out, to escape, while the larger ones are reserved, has been frequently suggested. The objection to this would be chiefly the fact that, owing to the delicate nature of the white-fish, it would not endure rough handling; and, if the regulation was established, there would be no probability of its enforcement. That it is in some measure practicable, if carried out, may be known from the fact that a fisherman, formerly in North Bay, Wisconsin, took his fish from the pound-net, one by one, and bled them before he threw them into the boat, the smallest were thrown overboard unharmed, and most of them swam off vigorously, though many died from handling. His purpose in bleeding was to pack a firm-fleshed, white-meated fish, for which he received a fancy price from some one in Ohio.

The enlargement of the mesh in the pot or crib is perhaps the most practical regulation that is likely to accomplish the purpose intended without inflicting injustice upon the fishermen. The mesh in present use is from one and one-half to three and one-fourth inches in length, extension-measurement—that is, measured through the length of the mesh-opening when drawn taut. This makes it from three-fourths to one and five-eighths inches from knot to knot. For the capture of herring, the smaller mesh is considered necessary, while, where the object is to capture only white fish, the larger mesh of three and one-fourth inches is sometimes used.

Comparing the gill-net mesh, usually four and one-fourth or four and one-half inches, with the pound-net mesh, it will be observed that the difference in size is not the only variation in condition to be considered. The fine twine of the gill-net is more unfavorable for the escape of a fish than the coarse twine or cord of the pound-net. Besides, while the gill-net, by means of nicely-balanced floats and weights, stands in the water comparatively slack, the sides of the pound-net are drawn up with the meshes open, and standing taut and firm, are much less apt to entangle a fish while attempting to pass through. It is seen from this that although four and one-fourth inches are small enough, perhaps too small, for the gill-net mesh, the same dimension is not required for the pound-net.

Still, with all the advantage that a taut, open mesh affords them, the habit of the fish to remain quietly in the "pot" until it is lifted to the surface has to be taken into consideration. Of course the greater facility of escape, the greater number of fishes that will avail themselves of it.

It should not be considered an unfair demand that all white-fishes of less size than the minimum of the inspection-grade No. 2 should be allowed the means of escape. By a series of measurements it has been determined that a No. 3 white-fish will measure about seven and three-fourths inches in the girth. This would require for its escape about three and three-fourths inches, extension-measurement, or one and seven-

eighths inches from knot to knot. To allow for shrinkage, after saturation with tar, the mesh when netted should be at least three and seven-eighths inches, extension-measurement.

There are a few localities in the lakes where herring are utilized to a large extent. In the shoal regions of the lakes, and especially in the shallow bays, the lake-herring are abundant. In Green Bay, an arm of Lake Michigan, to the south of the Menominee River, at Mackinaw, Mich., and vicinity, a good many lake-herring are handled, though they are by no means as valuable to the fishermen as either white-fish or trout. In the western end of Lake Erie, especially in the vicinity of Sandusky, Ohio, they are taken in large numbers. In all localities where fishing is carried on with the pound-nets, or near the shore with any nets, herring are taken to a limited extent, and are generally not made use of.

Of course when the fisheries depend on the catch of herring for their support, a large mesh would be fatal to them, and it is doubtful whether a mesh larger than one and one-half inches could be used with advantage.

The statistics of nine principal fish-markets on the lakes show the proportion of lake-herring handled to be one-sixth, while the low rates herring command in the market would produce only about one-thirtieth of the amount realized from the whole quantity of fish handled. This shows the small value of the herring, to the fishermen, in the herring-localities. In the whole product of the lakes it would be of much less consequence.

It will be seen, from the foregoing statements, that a law regulating the size of mesh, to the great advantage of the better species of fishes, would not be very injurious to the fishing-interests as a whole if it allowed the escape of the herring. Still, as the discovery has been made, this fall, that the herring feed very extensively on the spawn of white-fish, there is an advantage in taking them from the lake.

Prohibiting fishing at certain seasons of the year has been an ordinary method of legislation in protecting the fish, and has proved to be of great advantage in streams and inland waters. The great lakes, in the particular of fishing, assume very much the character of the sea, and the same class of legislation, benefiting streams and inland waters, is not required for them.

A close season, from Saturday night to Monday morning, has been recommended by State commissioners of some of the sea-board States. This could be adopted in the case of the pound-nets, but it would not be practicable with the gill-nets, as it would be nearly impossible for the fishermen to take up several gangs of nets on Saturday night, and reset them on Monday.

In the case of the pound-nets, the extension of leaders to great distances from the shore is an abuse of the fishing-privileges, as it obstructs, to too great an extent, the natural runways of the fishes, and

infringes on the rights of other fishermen, on each side, by preventing the access of fishes to their nets.

A law restricting the number of pound-nets to the mile, along the shores of the lakes, would be a favorable regulation.

The gill-netters, though having had much less influence in diminishing the numbers, would assist the increase, to a large extent, if they restored the mesh of the gill-net, now generally four and one-quarter inches, to the original four and one-half inch mesh. A discrimination should, however, be made in favor of Grand Traverse Bay, where the larger portion of the catch is the black-fin, *Argyrosomus nigripinnis* Gill, which does not attain an average weight of more than one pound.

A regulation prescribing the size of meter and seaming, and enforcing the renewing of the same, and also the stretcher-lines of gill-nets, would be valuable, as great numbers of fish are destroyed uselessly by the breaking away, in storms and currents, and loss of the nets in the lakes, which continue to capture fish until the floats become water-logged and sink to the bottom.

The catching of white-fish during the spawning-season, from November 10th or 12th to the middle of December, is often censured. It will be observed that though the ova at this season of the year are ready to be deposited, and produce, in the course of a few months, young fish, there are no more eggs destroyed at this season, in killing such fish, than at an earlier period. Nor is the production of the next season's stock of young fishes any more diminished by taking the same number of fishes from the water in November than in August. The objection to taking fish at this season is, that they run into shoal water, in large schools, and are taken in greater numbers than at any other season of the year.

There is no fault found with the quality of the fish taken in the cold waters of early winter, and the largest quantities can be handled with safety, because of the favorable weather.

The only run of fish the fishermen can look forward to, with certainty, is the run of trout upon the reefs in October, and of white-fish in the shallow waters in November. Though the previous months have been unprofitable, they look forward to this season with certainty of some success if it does not prove too stormy.

There is a wasteful destruction of fish in the killing of sturgeon in certain localities. In the waters of Green Bay they are taken by thousands in the early fall in the pound-nets. The fishermen make no use of them, and considering them an annoyance, draw them into the boat with a gaff-hook, and throw the carcasses on the offal-heap. Thousands of pounds of food are destroyed in this way every year.

The firm of Schacht Brothers have attained quite a degree of wealth during the past six years, in the city of Sandusky, Ohio, by utilizing the sturgeon. They smoke the thicker parts of the fish, making a superior substitute for halibut, manufacture caviare from the ova, isinglass from the bladders, and oil from the thin parts and offal.

Green Bay is, perhaps, the only locality on the lakes where this can be repeated with success, and it is well worth the attention of some one with a small amount of money to invest.*

It is the universal experience of fishermen that throwing offal on the fishing-grounds is offensive to the white-fish and destructive to the fishing-interests in the locality. A stringent law should be enforced in this particular, as it is generally a shiftless, lazy man who is guilty of this injury to his more worthy neighbors, as well as to himself.

In this connection it is well to refer to the fact that sawdust in many lumber-mill localities is thrown into the streams, or is used to bank out in the shoal waters at the edge of a river; great quantities of it floating out and water-logging, settle on the spawning-beds and feeding-grounds of the white-fish, to decay, and drive them from the locality.

With this discussion of the effects of different laws upon the fishing-interests we would refer to the enlargement of the mesh in both pound-nets and gill-nets, prohibiting the throwing of offal upon the fishing-grounds, and the useless destruction of sturgeon, as the most necessary and desirable regulations to be established by legislation.

It will be observed that the varying character of the fishing in different regions requires discriminative legislation in favor of certain localities. Where the lake-herring is the principal fish taken, a mesh larger than two inches would allow their escape. The provision of a close season, during the hot months of the summer, though, it will be seen, it would afford an ample season in the spring and fall for the fisheries in most localities, would debar all successful fishing to the larger extent of the Illinois shore, where this season of the year is the only time when fishing is attempted. The enlargement of the gill-net mesh to four and a half inches, though a favorable regulation for all other portions of the lake, should include an exception in favor of the region of Grand Traverse Bay, Michigan, where the black-fin, a fish averaging much smaller in size than the white-fish, is taken in large numbers.

The Canadian laws are sweeping and stringent in character. By exacting license-fees from the fishermen they control the extent of fishing in all localities, and limit the number of nets to each mile of the shore in accordance with the judgment of the fishery-officers. Their system of laws and policing the whole extent of shores is an expensive and cumbersome method of protecting the fishes, and it is altogether probable that the large amount of money, \$20,195 in the year 1871, used for this purpose, would increase the products of their fisheries to a much greater extent, if expended in the propagation of those fishes adapted to artificial culture.

18.—ARTIFICIAL PROPAGATION.

By far the more successful method, in restoring the numbers of food-fishes, is that of artificial propagation. During the past several years, the salmon in Norway, Sweden, Germany, France and the British isles,

* Since undertaken.

have been increased to a very large extent from the breeding-houses at Huningen, Stormontfield, and elsewhere. A yearly increasing supply of salmon has by this means stocked the exhausted rivers of Canada. The shad and alewives have been restored to many of the eastern rivers, and the brook-trout has been reared in great numbers, and many streams and localities where they had always been unknown have been stocked with this favorite fish.

Of all species except the shad, those of the salmon-family prove to be the best adapted for artificial culture. The eggs are readily impregnated, are specially adapted to being handled, to endure transportation, and lie free and separate at the bottom of the water, incased in an investing membrane thick enough to protect the delicate embryo from the hard contact of the gravel, or glass, or wire screens upon which it is necessary to place them.

(18a.) *History of the white-fish culture on the lakes.*—It has already been shown that by far the most important fish of the lakes is the white-fish. The fish culturists in the vicinity of the lakes, having the knowledge of the rapid decrease that had been going on in the numbers of this species for the past few years, appreciated the advantage that their art might afford should the white-fish prove to be adapted to their methods of culture.

Three prominent fish-culturists in the vicinity of the lakes began their experiment about the same time: Mr. Seth Green of Rochester, N. Y.; Mr. Nelson W. Clark, of Clarkston, Mich.; and Mr. Samuel Wilmot, of Newcastle, Ontario, Canada. Mr. Green and Mr. Wilmot obtained spawn in the fall of 1868, and Mr. Clark in the fall of 1869, and treated them in the same manner as the brook-trout. These experiments 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 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 special 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, Mich., 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. Wilnot, 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. Wilnot 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. Wilnot obtained a supply of white-fish spawn at Sandwich, on the Canadian side of the Detroit River.

November 11th 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 obtaining 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 table-spoon, 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 table-spoonful 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 one million three hundred and thirty thousand 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 table-spoonful 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, Neb., 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, Cal. 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 Institute 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 yolk, known to occur in the young 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 aerated 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, 35, 30, 18, 9, and 7 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 that both the 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 23 to 30 hours, or one-fourth of the time they continued in aerated water and unlimited space. Five similar observations were made on impregnated eggs, with 48, 38, 17, 10, and 7 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 76, 101, 127, 150, and 174 hours each, after impregnation, and two free embryos at 24 and 48 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 7 hours, and the yelk-contractions did not continue more than 18 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 Cali-

fornia 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 in 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° 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-fauna 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 fauna 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 come 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, manufacturing, 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 injury from 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.

The piscivorous fishes of the lakes are to be found almost entirely in the lesser depths. Of these the pike, *Stizostedion americana*, is the most destructive in the regions where it is to be found in numbers. Their number, however, does not at all approach that of the spawn-eating herring, and it is not probable that the white-fish suffer from their voracity in the earliest stages of their growth, but after they have attained a couple of inches or more in length. The regions where the pike is numerous are the western end of Lake Erie, Saginaw Bay, Lake Huron, and Green Bay, Lake Michigan.

The perch prevails in limited numbers throughout the whole extent of the lakes. The lake-trout is not found, within the range of the smaller white-fishes, in sufficient numbers to do them much damage. The habit of the young embryos to seek the surface is also a protection to them. There is not in the lakes a single surface-feeding fish, except perhaps a few small Cyprinoids and a *Chirostoma*, which are not piscivorous species. There is no savage feeder, such as the blue-fish, *Pomatomus saltatrix*, of the sea, that comes to the surface. So that at this stage of growth they are comparatively safe. There are also large schools of the Cyprinoid family found in the lakes at the same season of the year as the small white-fishes, and from the month of June until late in the fall large schools of embryo fishes are found in the waters, principally Cyprinoids. So that there is abundance at all seasons of the year to supply the appetites of the piscivorous fishes besides the young white-fish, and they, of course, suffer much less in consequence.

The increase of shad on the sea-coast has resulted from turning loose the embryos, when but a few days from the egg, where the piscivorous fishes are numerous, and an increase of equal or greater rapidity may be looked for in the white-fish, with comparatively few dangers to encounter.

(18 b.) *Breeding of salmon-trout.*—The breeding of the salmon-trout, *Salmo namaycush*, with the exception of the hatching of a few eggs by Mr. N. W. Clark, has been entirely in the hands of Mr. Seth Green, of Rochester, N. Y. His experiments extend from the fall of 1870 to the present, with continued success. The past season eggs and young of the salmon-trout were distributed to about seventy different persons, to stock the lakes of the State of New York.

F—ECONOMICAL AND NATURAL HISTORY OF THE MORE IMPORTANT FOOD-FISHES OF THE GREAT LAKES.

19.—DISTRIBUTION OF THE SPECIES ACCORDING TO DEPTHS.

(19 a.) *Vertebrate fauna.* Observations of the net-fishing at different depths made the fact apparent that there are quite well defined ranges, with reference to depth, in the fauna of the lakes; not that the lines are so distinct that fishes peculiar to a certain zone are not frequently found straying into the ones contiguous, but still so well defined that a fisherman of short experience, knowing the depths at which he is setting his net, can predict with confidence what species of fishes he will capture and what he is not at all likely to take. While a few of the deep-water fishes seldom or never approach the shore, there are many species, of the shallow waters, never taken in deep soundings. The migratory instinct of the spawning-season temporarily changes these habits in a few species, and there is considerable evidence to prove that the temperature of the water modifies the preferences of many fishes to certain depths.

As one or two fishes of the deepest zone are the most constant in their attachment to their limited range, it will be as well to begin with the deeper water, in describing the ranges of the species.

The fishes referred to are, a small Cottoid, the *Trigloopsis thompsoni* Gir.; and a Salmonoid, the black-fin, *Argyrosomus nigripinnis* Gill, (Mss.) These fishes are most abundant in seventy fathoms and deeper, and are seldom taken, in the fishing-season, even in as great a depth as fifty fathoms. At Grand Haven, Mich., where a line of steamers keeps the harbor open throughout the winter, the fishermen take the black-fin in quantities, within thirty or forty fathoms, in the month of December. This fish has thus far been found only in Lake Michigan. The *Trigloopsis* is only known from specimens taken from the stomachs of larger fishes in Lakes Superior, Michigan, and Ontario. The remaining species, of which a few are sometimes found at the depth of seventy fathoms, are the lawyer, *Lota maculosa* Les., the salmon-trout, *Salmo namaycush* Penn., the siscowet, *Salmo siscowet* Agass., the white-fish, *Coregonus albus* Les., and the cisco, (not the cisco of Lake Ontario,) *Argyrosomus hoyi* Gill, (Mss.)

At fifty fathoms, the nets take the five species last named abundantly. This may be considered, in the deeper lakes, the zone of the Mackinaw trout and of the cisco, throughout the spring, summer, and fall, with the exception, in the case of the trout, of the spawning-season.

Between twenty and forty fathoms the gill-nets take the salmon, or Mackinaw trout, with a few lawyers and ciscos.

From twenty fathoms to the shore are found the most numerous assemblage of species: The lawyer, *Lota maculosa* Les., one or two small Cottoids, *Uranidea franklini* Agass., and *U. richardsonii* Agass.; the sheephead, *Haplodonotus grunniens* Raf.; the black-bass, *Micropterus nigricans* Cav. and Val. and the small-mouthed black-bass, *M. salmoides*

(Lac.) Gill; the rock-bass, *Ambloplites rupestris* (Raf.) Gill; the perch, *Perca flavescens* Cuv.; the wall-eyed pike, *Stizostedion americana*, (Cuv. and Val.); the sauger, *S. grisea* (DeKay); the blue-pike, sp. n.; the white-bass, *Roccus chrysops* (Raf.) Gill; four (?) species of Etheostomoids; *Chirostoma siccolum* Cope; the sticklebacks, *Gasterosteus inconstans* Kirt.; *G. nebulosus* Agass., and *G. pygmaeus* Agass.; the lake-pike, *Esox lucius* Lin.; the muskellunge, *E. nobilior* Thomps.; the mud-minnow, *Umbra limi* (Kirt.) Gunth.; a few Cyprinodonts; *Percopsis guttatus*, Agass.; the white-fish, *Coregonus albus* Les.; the Menominee white-fish, *Coregonus quadrilateralis* Rich.; the lake-herrings, *Argyrosomus clupei-formis* Mitch., and *A. harengus* Rich.; the speckled-trout, *Salmo fontinalis* Mitch.; the moon-eye, *Hydon tergisus* Les.; the saw-belly, *Pomolobus chrysochloris* Raf.; the mullet-sucker, *Ptychostomus aureolus* (Les.) Agass.; the spotted-sucker, *P. fasciatus* (Les.); the long-snouted sucker, *C. hudsonius* Les.; the common pink-sided sucker, *Catostomus communis* Les.; the black sucker, *Hylomyzon nigricans* (Les.) Agass.; the carp, *Carpionodes cyprinus* (Les.) Gunth., and eighteen (?) species of Cyprinoids; the bull-head, *Amiurus catus*, Lin.; the great lake cat-fish, *Amiurus nigricans* Les.; the fork-tailed cat-fish, *Ictalurus caroleus* Raf.; the yellow back-tail, *Noturus flavus* Raf.; the dog-fish, *Amia calva* Lin.; the bill-fish or gar-pike, *Lepidosteus osseus* Lin., and *L. platystomus* Raf.; the sturgeon, *Acipenser rubicundus* Les., and the lamprey, *Petromyzon*. In this zone is also found the Amphibian *Menobanchus lateralis* Say.

It will be observed that the lawyer, the white-fish, and the lake-trout, are found in all depths in more or less abundance. This is a fact, not only in the spawning-season, but at all times. The trout, however, are comparatively rare inside of a depth of about thirty fathoms in the deeper lakes, except during the spawning-season; and the lawyers are only taken in quantities outside of forty fathoms in the spring of the year.

(19 b.) *Invertebrate fauna.* The invertebrate fauna of the bottom has been investigated to a limited extent by dredgings.

This work was initiated by the Chicago Academy of Sciences, in the year 1870, in the shallow water off Chicago Harbor. Dr. Stimpson reported finding but little life in this vicinity—insect larvæ, a leech, small mollusks, mosses, and algæ.

Later in the season a tug was employed at Racine, and a party, including Drs. Stimpson, Lapham, Andrews, Hoy, and Mr. E. W. Blatchford, made dredgings in from thirty to sixty-four fathoms, resulting in finding the lake-bottom thickly inhabited by two genera of small crustaceans, *Mysis* and *Gammarus*, a planarian, and a small mollusk, of the genus *Pisidium*. The crustaceans were determined by Dr. Stimpson to be the same as those which Dr. P. B. Hoy had taken from the stomach of the white-fish, in a partially digested state.

In August of 1871, under the direction of General C. B. Comstock, of

the lake survey, Professor S. I. Smith made extensive dredgings in Lake Superior, working out the bottom fauna very thoroughly, and discovering some fourteen new species of invertebrate life, and eleven other forms previously described, distributed from the shores out to one hundred and sixty-nine fathoms in quite well-defined zones.

In September of 1871, on receipt of the notification that the revenue-steamer Andrew Johnson had received instructions to afford facilities for the examination of the fauna of the lake-bottom, a small dredging-outfit was received on board, and as full collections made as the stormy weather of the trip permitted.

The Academy of Sciences of Chicago furnished a large part of the outfit from their stores of apparatus; and Mr. E. W. Blatchford, of Chicago, supplied a quantity of lines and nets, among the rest a trawl-net used by him in collecting off the coast of Florida for the museum of the Chicago Academy. This apparatus, with the dredging-collections of the trip, and the entire collections made on Lake Michigan, was burned, with the academy, in the great fire of that year.

Dr. Stimpson had previously worked up the collection, and identified the species as the same as those of his dredgings.

The trawl-net was used in thirty fathoms in Grand Traverse Bay, but failed to take anything, as there are probably no fishes in the lakes, other than the smaller species, of so little activity as to be unable to escape capture from a twelve-foot trawl.

The dredgings were made in from twenty-six to one hundred and forty-four fathoms. The small forms of life were found to be abundant at all depths, and the bottom fauna was found to be quite uniform in the region of the lake examined. The different dredgings have made it evident that the invertebrate life of the bottom is all small forms, though so abundant as to afford food for unlimited numbers of fishes.

The stomachs of the white-fishes examined in many localities were found gorged with the crustaceans and mollusks which they had found in the bed of the lake.

In the month of August, while making the tour of the northern shores of the lake, in a Mackinaw boat, the dredge was carried over to Torch Lake, in the Grand Traverse region of Michigan. This lake is nearly eighteen miles long, with an average width of two miles. Its outlet is first through a shallow creek, then through two connecting lakes, and through a sharp and shallow rapid into the bay. Earlier in the season, with a roughly-prepared map in hand, I had sounded the lake through about eleven miles of its length, to determine its average depth, which was found to be forty fathoms, the deepest soundings being forty-five fathoms.

The hauls of the dredge discovered the same species of invertebrates found in Lake Michigan. The fishes of Torch Lake are also the same as in the main lake, its transparent waters harboring none of the property river or stream fishes.

The deep trough of Torch Lake is the eastern one of a series, with a general north and south direction, easily traceable in the United States Army engineers' chart of the north end of Lake Michigan, which forms a notable feature in the submarine topography of the lake.

Two other lakes in Michigan, in which the white-fish are said to make their home, are Crystal Lake, near Frankfort, and Higgins Lake, in Roscommon County. There are also a few small lakes into which they have been introduced.

L. J. Farwell, ex-governor of Wisconsin, introduced the white-fish into the lakes at Madison, in the year 1850.

20.—THE SALMON OR MACKINAW TROUT, *Salmo namaycush* Penn.

The trout of the great lakes is one of the three most numerous fishes, and, except the sturgeon, attains the greatest weight of any of the lake-fishes. It is captured almost exclusively by the gill-nets, the pound-nets in some portions of the lakes taking them during the spawning-season. In winter a great many are caught in the bays, through holes cut in the ice. They are found in all of the great lakes and in a few inland lakes in their vicinity.

As compared with the white-fish, their merits as a fresh fish are relative to taste, though the greater number would decide in favor of the latter. Salted trout bring a lower price in the market than white-fish, as they are inferior to them as a salt fish.

Their migrations, as far as observations have been made, are confined to the spawning-season. They do not ascend the rivers, and although they are known to be in a few inland lakes connected to the main lake by rapids, there seems to be no knowledge of their ever having been seen or taken in the outlets.

Their range of depths at other seasons than the spawning-period is in deep water. A few stragglers occasionally approach the shore, and are taken in the pound-nets, or with the hook, from the piers extending into the lake. In the northern portions of Lake Michigan they are taken in depths of fifteen fathoms, in small numbers, by the gill-nets, and more plentifully through the ice in the winter time, though a depth of over thirty fathoms is the most favorable ground for their capture.

In the shallow waters of Lake Erie, in the western part of the lake, they are scarcely found at all, though numerous in the deeper portion, east of the city of Cleveland.

The lake-trout is a ravenous feeder. The fishermen say of him that "he always bites best when he is the fullest."

In Lake Michigan, where the investigation of the character of their food was carefully made, it was found to be principally the cisco, *Argyrosomus hoyi* Gill. Mss. The prevailing notion that they feed largely upon the white-fish was not confirmed by these observations. Although it was continually asserted by the fishermen that the stomachs of the trout were found full of young white-fish, there was no instance under my

observation where it was so. During 1871 no opportunities were omitted to observe the stomach-contents of the trout, when they were sufficiently undigested to determine the species, and often, when, to confirm the repeated assertions, a fisherman would throw out the contents of a stomach, to show me the young white-fish, the head and mouth invariably indicated the genus *Argyrosomus* Agass., and he would readily admit his mistake.

Questioning fishermen closely, who asserted that they found the young white-fish to be the principal food of the trout, they generally assented that they had not given close enough attention to decide positively between young white-fish and the cisco, though many gave testimony of finding unmistakable white-fish, of mature size, in the stomachs of the overgrown trout taken in portions of the lakes.

Stragglers into the shoal waters, and the trout migrating into shallow places, to find their spawning-grounds, would undoubtedly prey upon the smaller white-fish as readily as they would upon any other species; but during the larger part of the year they make their home in deeper water than the young fish are found in.

An instance was related, in 1871, of a large trout having swallowed a smaller one, which the fisherman removed from its stomach in a good state of preservation.

It is not an unusual thing for a trout to swallow a fish too large for the capacity of his stomach, and the tail protrudes from his mouth until the forward part is digested. A trout measuring twenty-three and one-half 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 fourteen inches without the head, which had been digested.

Their exceeding voracity induces them to fill their maws with singular articles of food in the bill of fare of a fish. Where the steamers or vessels pass, the refuse from 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, and in one instance I heard of a fragment of a ham-bone.

They are readily taken with a hook baited with pieces of fish. They are a sluggish fish to pull in, taking hold of the bait with a tug at the line and then allowing themselves to be pulled to the surface, with no more vibration in the line than if a heavy sinker was the weight at the end. Parties going out with the fishermen often take a large number while the nets are being lifted, and in some localities the largest of the trout are taken in this way. While becalmed near Summer Island, in Lake Michigan, in 1871, two of us, in about one hour's time, took in fifty pounds of trout, in seventeen fathoms of water.

The explanation that the red color of the flesh of certain species of this family is attributable to the red pigments of crustaceans, which form a principal article of food, is very directly contradicted in the ex-

ample of the Mackinaw trout and the white-fish. In this trout the very deepest tints found in the flesh of the salmon are frequently to be seen, while the food of the trout is almost wholly fishes, and in no case crustaceans; while in the white-fish the flesh is of the purest white, and the food is almost wholly crustaceans, and largely of *Gammaridae*, with a considerable amount of the red pigments referred to in their shells.

The spawning-season of the trout begins about a month earlier than that of the white-fish. The details of their habits I can only give from information I have gathered by continually questioning fishermen and others who have had better opportunities of observing them than I have. 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 on to the spawning-ground a week or more earlier.

At Detour, at the head of Lake Huron, on the 16th 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 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. Near Milwaukee, on a reef at about the greater depth named, is a spawning-ground, from which for years a large type of trout has been taken. The spawning-grounds are found from Racine north on the western shore of Lake Michigan, and from a little to the northward of Saint Joseph north on the eastern shore. The spawning-ground nearest Saint Joseph is said to be a clay bottom. At Detour the nets were set so close to the shore that the tips of the floats showed above water.

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.

The ovaries from a Mackinaw trout of twenty-four pounds weight were preserved, and weighed three pounds four and one-fourth ounces, and contained fourteen thousand nine hundred and forty-three eggs; the calculation being made by counting a fractional weight.

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 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, Mich., 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.

There are no species of fishes in the lakes 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 *chivoicha*, *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 decrease in lake-trout is not so apparent as it is in the white-fish. The pound-nets have not made the extensive inroads upon their numbers,

and none but mature fishes are taken. The larger ones are less numerous; and it is claimed that the average weight of the trout caught is less than in former years.

Like the other Salmonoids, the trout have proved to be well adapted to artificial culture. The one drawback with them is the difficulty of obtaining the spawn in the fall of the year, when the rough weather renders the visits to the spawning-grounds a matter of hardship and danger.

21.—THE SISCOWET, *Salmo siscowet* Agass.

This interesting fish is confined, so far as known, to Lake Superior alone. In a few localities in that lake it is very numerous.

With rare exceptions of young specimens, found near the shore, it is taken entirely with the gill-nets in deep water. It is a remarkably fat fish, and, as a fresh fish, is very inferior for the table. Even boiled, it is oily and rank in flavor. As a salt fish, packed in brine, it is most excellent, and is universally admitted to surpass either white-fish or trout. Its range of depth is outside of forty fathoms. How much deeper than this it may be found I cannot tell, as no fishing at greater depth than fifty fathoms came under my observation in Lake Superior. The stomachs were found to be filled with a Cottoid. This seemed to be its entire article of food in the vicinity of the Apostle Islands.

The flesh varied from nearly white to a light reddish tint, not so deep-colored as is found in the salmon and the Mackinaw trout.

They spawn earlier in the fall than any of the other Salmonoids in the lakes. By the latter part of August the spawn in some of them is ripe and running freely, while in the month of September the females are all ripe and depositing spawn. They seemed to have no migratory instinct at this season, but were taken while spawning in the same vicinity where they had been taken for weeks previously.

The ovaries from three specimens of mature females contained the following quantities of eggs:

Weight of fish.	Weight of ovaries.	Number of eggs.
5 pounds.....	<i>Ounces.</i> 12	2,796
5 pounds.....	10	3,120
.....	12	3,750

We have no knowledge of the time it requires the eggs to hatch, nor any data with reference to the growth of the fish. The young ones probably remain in deep water, as they are not taken in the pound-nets, and frequently quite small ones are found in the gill-nets. They will average about four and one-half pounds in weight, the largest coming under our observation weighing about eight pounds.

The enemies with which they would have to contend are probably few. The white-fish lives in the vicinity of their spawning-beds, and as it is known to be a spawn-eater, it probably makes food to some extent of the eggs of the siscowet, though in the early days of September, when we had opportunity to examine the white-fishes' stomachs, no eggs were noticed. The food of the Cottoid we were unable to learn, as the only specimens we obtained were from the stomachs of the siscowet, and nearly digested. It is quite possible the eggs form part of its food.

One external parasite was found to be numerous, a Lernean, and the intestines were generally infested with tape-worms in abundance.

22.—THE WHITE-FISH, *Coregonus albus*, Les.

(22 a.) *General considerations.*—The species of the genus *Coregonus* are widely distributed through all the northern regions of both hemispheres, from about 46° latitude in the Old World and 41° 30' in America, to the Arctic seas. They are the most extensively used of all fresh-water food-fishes, unless it be the carp of China or the genus *Salmo*.

They inhabit all the deeper lakes in the regions referred to, the rivers of the more northern latitudes, and some of the species, if not anadromous, live indifferently in either the rivers or the sea. Specimens from Hudson's Bay are in the possession of the Smithsonian Institution, and in Pallas's *Zoographia Rosso-Asiatica* several species of the *Coregoni* are described as ascending the rivers from the sea. They have been a most extensive food-resource to the Indians, pioneers, trappers, and hunters of the vicinity of the great lakes, and throughout British America and Alaska. The statistics already given indicate the extent of their use in the older and more thickly populated region of the country.

The white-fish has been known since the time of the earliest explorers as pre-eminently a fine-flavored fish. In fact there are few table-fishes its equal. The testimony of very many summer travelers, this season, on Lake Superior, from Eastern States gave preference to the white-fish over the shad, both for flavor and its almost entire freedom from bones. To be appreciated in its fullest excellence, it should be taken fresh from the lake and broiled. Father Marquette, Charlevoix, Sir John Richardson, explorers who for months at a time had to depend on the white-fish for their staple article of food, bore testimony in their writings to the fact that they never lost their relish for it, and deemed it a special excellence that the appetite never became cloyed with it.

The fact that the white-fish is loth to take the hook is sufficient to prevent much interest in it from a large class of people. There is danger, in the work of fish-culture in this country, of conceding too much importance to this point in the habits of a fish. The fish-interest of the country has a much larger stake in the protection and increase of the staple-food fishes than in the game-fishes simply as such; although it might readily be acknowledged that among all other sporting recreations angling was the most sensible. Seth Green, in his magnificent

success in restocking the rivers of the Atlantic slope with the shad, did a work of far greater importance than he with other fish-culturists have done in the propagation of trout.

The cod, mackerel, herring, white-fish, shad, salmon, and salmon-trout, deserve the principal attention in the efforts at increase.

With the three first-mentioned artificial propagation has nothing to do at present; probably never will. Of the others the white-fish is the most important as a food-resource, because of its numbers and because it can be obtained at all seasons of the year.

In adaptability to artificial propagation it is probable the shad has the advantage because of the rapid development of the eggs. But there is still a difficulty in the way of the propagation of an unlimited number of shad, in the fact that the streams to which they formerly resorted are obstructed by numerous and high dams. There are no obstructions of this character to interfere with the white-fish; and in the great lakes, if it were advisable, there is nothing apparent in the way of the propagation of unlimited millions.

The character of its food has also a bearing on its adaptability to rapid increase. There is considerable loss among the speckled trout from the larger ones preying upon the smaller. In England the salmon have been accused of the same habit to some extent, while the young are in the parr and smolt stage. But nothing of this kind will ever deplete the numbers of the white-fish. Invertebrate forms of life constitute its entire food. To some extent it will suffer from the rapacity of other fishes, but, as shown on other pages of this report, in a state of nature the ova-stage is the one in which the greatest loss is suffered.

(22 b.) *The food of 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 investigations 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 *Gammaridae* and *Mysidae*; 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 *Gammaridae* constituted the principal food. In shallow regions small *Conchifers* were more nu-

merous. 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 Sainte 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 contained principally the *Mysidae*.

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 Sainte Marie, has frequently taken them in that locality with a hook baited with a May-fly, *Ephemeroidea*. 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.

(22 c.) *The migrations of the white-fish.*—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, Ills., 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 places on the shores of Lake Michigan, in the south half of the lake, in 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 in 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 yet 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 aeration 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 aeration 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 Septem-

ber, weakens the force of the theory that the aeration 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 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 aeration 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.

(22 d.) *The habits of the white-fish during the spawning-season.*—The anadromous habit of the salmon is shared by their relatives, the *Coregoni*, to a considerable extent. Several species are known to ascend the rivers of Northern Asia and Europe, from the Arctic Sea. These migrations, as described by Pallas, though they have not, perhaps, in all species, a close relation to the time of spawning, in a few are quite evidently for that special purpose, as, in his *Salmo clupeoides*, *Coregonus merkiti* of Gunther, he says they ascend the rivers during the autumn, and return again when the ice forms.

Others live indifferently in fresh and salt water. There are specimens, in the National Museum, of white-fish collected by the late Mr. Drexler, from Hudson's Bay. Some eight or nine species of the Arctic regions

are found in both salt and fresh water. The *Coregonus quadrilateralis* Rich., of Lakes Superior, Michigan, and Huron, was found by Richardson in the Arctic Ocean.

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 in shore 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 Cottleville, 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, *Stigiostedion 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 Sainte 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 day-time, previous to 4 or 5 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.
	<i>Ounces.</i>	
2 pounds.....	5½	21,229
2½ 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.

(22 e.) *Habits of brook-trout during the breeding-season as compared with those of the white-fish.*

A comparison of the habits of the male and female white fish with those of the trout, *Salmo fontinalis*, and of the salmon, is interesting, from the entire difference of their conduct toward each other, and the manner of depositing the spawn.

The male brook-trout, in his behavior to his mate, is a cavalier of the first order. His colors are at their brightest, and his fresh and bright appearance makes him one of the handsomest inhabitants of the northern waters. Instead of driving the female and annoying her with a persistent worrying, as is the case with the white-fish, his whole wooing is

the most polite attention and the gentlest of persuasions. He moves continually to and fro before her, parading his bright colors, while she rests quietly, with her head up-stream, vibrating her fins just sufficiently to prevent floating down.

While at Mr. H. F. Dousman's breeding-house, near Waterville, Wis., early in the winter, I had the opportunity of observing the habits of the trout on their spawning-grounds. 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, by strong sweeps and flappings of her caudal fin against the bottom, in excavating a cavity in the bed of gravel.

December 14.—A pair of large trout were frightened away from their nest 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.

December 15.—Carried out a buffalo-robe and shawl to the top of the flume, near the head spring. Found a pair of trout in possession of a nest. They fled at sight of me, and having got comfortably settled in the robes, I lay quietly for fifteen minutes before the male approached. He swam directly over the nest, and examined in the vicinity for a few seconds, and then swam off to find his mate. A close observation detected a scar on his side, possibly received in a battle with some other male. It served as a very distinct mark to identify him among others. He returned to the spot once, driving off another male before she came with him. They moved along in the vicinity of the nest, she turning and swimming away for a short distance once or twice, and he attending her devotedly. She finally settled in a nest about five feet from my position. He drove away a small trout several times without any very violent demonstrations. She soon began to turn in the nest as if examining its condition, and again settled quietly, keeping up the slow fanning movement with her tail, the anal fin brushing the pebbles as large as pigeon-eggs that were in the cavity.

Soon after she rolled on her side, made three convulsive flutters, striking the pebbles with her tail, and sending up a little cloud of gravel and sand. Immediately afterward she turned short round, as if looking at the condition of the nest, or its contents, and once I thought I detected her in taking some gravel, possibly an egg, in her mouth. She lay resting quietly on the bottom for a short time, while the male played

back and forth around her. She moved away from the nest after a while, visiting some nests in the vicinity that probably contained the eggs of other trout, but soon returned to her own nest. The male attended her very closely, and, as they returned to the nest, resting for a second near her, he curved his body slightly, bent the dorsal fin to one side, and with his body strained to rigidity, a slight tremor was observed, and he again moved away. About once in ten minutes the fluttering occurred on the part of the female; a little cloud of sand was stirred up, but I looked a long time in vain for an egg. At last one was thrown upward with the sand, and the male coolly swam toward it, opened his mouth, and it disappeared down his throat. His oft-recurring rigidities and tremors seemed to have no special connection with her throes, or the possible emission of eggs, which I suspected at these times, though without any evidence of sight. He was very brave in driving off the males that approached, but one large one came twice, while I was watching them, that he did not attack, but swam in between him and his mate several times, with an evident intention of keeping him from her. The stranger, however, in both instances placed himself near the female, and the same curving, and rigidity, and tremors were observed.

The last time the rightful groom swam away with the stranger, who gave him several punches with his jaws. The evident intention of the former seemed to be to entice the intruder away from the nest. He escorted him off for a long distance and returned again to his mate. After three hours' observation of similar maneuvers, I left them to pursue, undisturbed, their singular actions.

The whole conduct of the male toward the female was a continued series of caresses. He spent his whole time in circling around her, rubbing against her, and wheeling away to return again, and exhibited every evidence of jealousy when other males approached. No violence to the female was offered at any time by her mate, though I saw him twice bite her gently while the stranger-trout was near, as if communicating to her.

Seth Green, who has occupied hours in observing the movements of trout, thinks the whole movements I had the fortune to observe, were merely the usual actions of trout just subsequent to the time of spawning. They serve, however, to contrast the conduct of the male toward the female with that of the white-fish. Mr. Green says that occasionally when the female tries the patience of the male too long in refusing to enter the nest, he suspends moral suasion for a time and hurries her toward the nest with a vigorous use of nose and jaws. A vertical movement over the nest, and occasionally the pair locking their jaws together, as they rose, was what Mr. Green observed whenever the eggs were emitted by the female.

The brightness of the skin and colors, the white margin on the under fins, and the comparative thinness of body, distinguish the male at the spawning-season from the female, who is dark-colored, the outer rays

of the under fins tinged with blue, and the abdomen swollen at this period.

(22 f.) *Development of eggs and embryo.*—It has been proven by repeated observation 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 from 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 fifty degrees. 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, Ill., until thirty-six hours after they left Ecorse, Mich. 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, Ill. 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.

(22 g.) *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 craw-fish 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 *Lens*, 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 No. 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 niagara*. 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."

(22 h.) *Rate of growth of white-fish.*—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, Mich., 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, Mich., 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) increase 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 afterwards 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.

A very excellent opportunity of observing the sizes attained by the

brook-trout at different ages, was afforded at Mr. H. F. Dousman's hatching-house at Waterville, Wis.

There is a more uneven growth in the trout of the same season than among any of our familiar domestic animals, such as sheep, pigs, or chickens.

Mr. Dousman's fish of the season, hatched in January and February, measured at the time of my visit, October 25, from two and one-half to five inches in length; while his trout of the previous season, about one year and eight months old, were from seven to fourteen inches in length.

Mr. Dousman is a large feeder, supplying his fish with food regularly twice a day throughout the year. He has the most perfect arrangements for keeping his fish of different ages separate, as there is no possibility of their getting together other than being dipped out of one of the box-flumes in which they are separately confined and dropped through the trap-door of another.

The same great variation is found to occur in the parr and grilse stage of the salmon, and is probably the case with all the species of the *Salmonoidæ* at all ages, the lake white-fishes included.

(22 i.) *Average size of mature fishes.*—The average size of mature fishes, in different localities, varies greatly. The white-fish of the region of the Apostle Islands is a medium-sized fish. The entire catch of the numerous fisheries in their vicinity should not be estimated higher than one and a half pounds for all the fish marketed.

In Thunder Bay, on the northern shore of the lake, a lift seen in October contained fish that averaged about the same as at the Apostle Islands.

Mr. George Barnston, of Montreal, a naturalist, connected in former times with the Hudson Bay Company, says, with reference to the white-fishes of Michipicoten Bay and River: "The produce of our own seines and nets I always regarded as composed of one species of white-fish, and the same as that caught everywhere in the lakes."

A large type of white-fish is reported from localities in the western half of Lake Superior, taken at certain seasons. Mr. E. Alvord, of Sandusky, Ohio, took a white-fish at Madeline Island, one of the Apostle Islands, weighing twenty-two pounds and a half. Stories, not well authenticated, of specimens weighing twenty-four pounds and over, are common on Lake Superior.

In White-Fish Bay a type of white-fish is taken, said to average very large. A specimen was forwarded to Buffalo from this locality, this season, weighing twenty pounds.

In Bachewauna Bay, opposite White-Fish Point, Mr. Barnston speaks of the white-fish as longer, and much thicker and heavier, than those of Michipicoten.

At the foot of the Sault Ste. Marie Rapids the Indians fish in the swift current, from birch canoes, with large dip-nets, taking a type of white-

fish, in large numbers, that will average four pounds in weight. A specimen was obtained of one of them this season weighing twelve pounds.

The white-fish from the greater portion of Lake Michigan will average lower than those of Lake Superior. A locality on the north shore of the lake has a very large type of white fish, of which the average of lifts I have seen brought to the shore could not be less than four pounds. I was informed that eleven white-fish had been put into a package weighing one hundred and seven pounds and shipped to a man at Charlevoix, whom I afterwards saw and heard him repeat the fact. The gill-net mesh in use at this point was one-half inch larger than that of most points on the lake. Two specimens obtained at Point aux Barques weighed respectively ten and eleven pounds.

Lake Huron white-fish are moderately large. From the western end of Lake Erie a large type of fish are taken. Those ascending the Detroit River in the fall of the year average two and a quarter pounds. From the eastern portion of the lake the white-fish are smaller. The average of Lake Ontario fish is small.

(22 j.) *Ranges as to depth favored by young white-fish.*—It is quite evident that the young and immature white-fishes confine their range entirely to the shallow waters near the shore. The pound-nets set in from twenty to forty-five feet catch numbers of small fishes seven or eight inches in length weighing only a few ounces. The capture of a white-fish as small as seven or eight ounces is a very rare occurrence with the gill-nets, for which twelve or fifteen fathoms is the least depth ordinarily employed. Though making this a special point for observation during the tour of Lake Michigan, not a single specimen as small as eight-ounces was seen among fishes taken from the gill-nets, and the percentage of fish as small as one pound in weight before dressing was inconsiderable.

A further confirmation of the in-shore range of young white-fish is in the fact that the catch of a pound-net set on a thirty-six-foot shoal, six miles from the land at Bay de Noquet, contained only Nos. 1 and 2 fish.

The head and mouth of the white-fish are so constructed that it is to a slight extent better guarded against entanglement in the mesh than its congeners, the lake herring and the cisco, so that there is a possibility that the small fishes pass through the meshes and escape capture. Still it is likely occasional ones would be taken, as all species taken by the gill-net are frequently found entangled about the body and fins, without any threads fastened in the mouth or even in the gills, and this often with the slender herrings and ciscos.

The fact already referred to, that no young-white-fish were found in the stomachs of the lake-trout, has an application here. The range of the trout in the warm season is in deep water, and as it is altogether likely the trout would make food of the smaller white-fishes if they were

to be found, the inference is natural that they do not range into the deep water.

From these observations it was evident that the white-fish were not found in any abundance in the deeper waters smaller than one and one-fourth pounds, and it is not until they attain about this weight that their migrations into the deeper waters of the lake begin.

From the examination of stomachs of immature fishes, the food was found to be small crustaceans and insects.

(22 k.) *Enemies of the white-fish.*—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," *Menobranhus lateralis* Say is very numerous in some of the streams and portions of the lake-shore. Mr. George Clark, of Ecorse, Mich., 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, Mich., states that some three years ago an epidemic seemed to prevail among the *Menobranchi* in Grand River, in the month of June and that their dead carcasses were washed ashore by hundreds, so that they lined the banks of the river, and the mill-men 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, Ill., 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 inches 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 *Paludinidae* and even *Limneus* 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.

The white-fish stomach is generally found to contain a few fish-eggs, though its principal food is the crustacea. The habit of leaving the shore immediately after spawning probably prevents it from being an agent in diminishing its own numbers.

The natural casualties of storms, deposits of sediment, smothering the eggs, the vegetable growth found to be so fatal in the hatching-troughs, are to be considered in this connection as the dangers, though more fully represented on another page.

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 craw-fish, 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. This point has been fully considered on a previous page, and the evidences disproving it related.

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.

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 Ichthyobdellan, a leech of three-fourths of an inch long, grayish white in color, with brown tessellated 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, Wis.

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 caecal tubes.

23.—THE LAKE-HERRING.

The so-called lake-herrings, *Argyrosomus clupeiiformis*, (Mitch.,) and *A. harengus* (Rich.,) are very numerous in the shoaler waters of the lakes.

In the shoal regions of Green Bay and Lake Erie they are found in vast schools, crowding into the pound-nets in masses until the "cribs" are filled to the surface of the water. In Lake Erie frequently a corner of the net is lowered and a large proportion of them allowed to escape before the remainder are thrown into the boat. Although they have been taken in this way for years, there is no apparent diminution in their numbers. Perhaps the little disposition on the part of the fishermen to catch them in some measure accounts for this fact, though there must be, as well, some natural advantages in their prolificity and in the tenacity of life of the egg. They are little sought after because they are not a favorite fish in the market, being rather deficient in qualities as a fresh or salt fish, though having no objectionable flavor. They are small and thin when opened, and become shrunken when pickled. A mode of curing them, lately adopted at Waukegan, Ill., and Sandusky, Ohio, makes them the most delicious food. It is merely a slight pickling in salt brine, and then exposing them to the smoke of a hot fire for a short time. By this process they are prepared for eating without any further cooking, and are very much superior to the ordinary smoked herrings. They will keep two or three weeks in hot weather when but slightly smoked. The profit on them to the fishermen is less than any other fish handled from the lakes, because of the low price they command in the market, and the expense of dressing and packing is much greater than in white-fish, trout, or pike, because of their smaller size.

The greatest length attained in an overgrown specimen seen at Point Edward, on the Canadian side of the head of Saint Clair River, was about nineteen inches in length, and it weighed about two pounds. The average length is scarcely one foot and the weight about nine or ten ounces.

Differing from the white-fish in the construction of the mouth; it being terminal, they more readily take a bait, and may be fished for with hook and line with a suitable bait. Insects are the best for this purpose, though they are frequently taken with a minnow. The contents of the stomach have been obtained in but a few instances, the fish being taken almost exclusively in the pound-nets, and in these they have generally remained long enough to digest the stomach-contents. A few specimens from seines in the Detroit River were found to contain insects and a few of the *Gammaridæ*, but no remains of vertebrates, though the herring are frequently taken with a minnow bait. They were found, by examination of the stomachs during the spawning-season of the white-fish, to be spawn-eaters of the worst character, their stomachs being crammed with white-fish ova, and, considering the great numbers of the herring, and their vicinity to the spawning-grounds, the destruction they effect must be very great.

Although a very general opinion prevails, in different parts of the lakes, that the herring spawns earlier than the white-fish, the opportunities afforded for observation, this season, indicated otherwise.

In Green Bay it was asserted that the herring came on to the shore in masses about the 6th of November, and although they were found in more or less abundance at all seasons of the year, there was a very evident general movement at that time. The only positive evidence of the fact of spawning is the emission of spawn by the fish when handled, and the migrations of the schools and the mere fact that the spawn are large does not determine the season of spawning. In regions where fishing is not carried on late in the season, it is a very common habit among the fishermen to conclude on some particular time during the fishing as the spawning-period, basing the belief on migration or appearance of the spawn, when, in reality, the fish do not spawn until after the fishing-season closes.

By November 25 of last year, the majority of white-fish in the western end of Lake Erie were found to have finished spawning. With few exceptions the ovaries were emptied of their load of eggs; the abdomen was wrinkled and flaccid, and but few eggs were emitted when thrown into the boats or on the fish-house floor. The lake-herrings at this time were found to be full of ripe eggs, which were voided from the ovipore of females whenever the fish was moved, and even while lying in heaps on the bottom of the boats or floors of the fish-houses. Earlier than this, between the 1st of November and the 20th, examination of the ovaries on nearly every day had found, in the larger proportion, the ovaries hard and compact.

The herring were taken at this time in their usual haunts, the pound-nets capturing them in immense quantities, making it probable that they do not change their locality in the spawning-season. What their subsequent habits may be, would require observation later in the season than fishing is generally carried on, though the new custom of allowing pound-nets to remain until the ice has covered the bays would afford a favorable opportunity. If they remain upon the spawning-grounds they would undoubtedly be their own worst agent of destruction.

In the winter of 1871, in Green Bay, to the south of Escanaba, Mich., it was discovered that the herring had congregated in large numbers in an open space free from ice next to the shore where a number of springs in the bank supplied a quantity of water of too high a temperature to freeze readily. Minnows were found crowded in masses at the water's edge, and using them for bait the herring were taken in large numbers, and occasionally a white-fish from about twenty inches of water.

All that is known of the time of hatching of the herring ova is from the experiments of Mr. Seth Green.

In the report of the commissioners of fisheries for the State of New York for the year 1871, it is stated that a quantity of the impregnated

spawn of the lake-herring was obtained and treated similarly to the white-fish ova. It is stated that "their time of incubation is about the same [as the white-fish.] The newly-hatched fish are very small, not exceeding three-eighths of an inch in size. The umbilical sac lasts but a few days, and the fish begin to swim and feed as soon as they come out of the shell. They are as active at one day old as the trout at two months. The young fish, being so small and delicate, are, of course, hard to keep. * * * They have increased in size faster than the white-fish, and the indications are that they are a more hardy fish and more easily raised."

The ovaries of a specimen examined weighed two ounces, and contained sixteen thousand and forty eggs.

At Waukegan, Ill., from a seine-haul on the 23d of June, a number of young herring were swept in with the larger fish, measuring from three and one-third inches to four and a half inches. At the rapids of the Sault Ste. Marie River a number were taken, from among the rocks near the shore, on the 2d and 3d of July, that measured from two and five-eighths inches to six inches in length. It is probable that the smaller grade were the fishes hatched the previous year.

On the 3d of December last herring were taken with a minnow-seine, at Point Edward, measuring from five inches to the size of mature fishes, the smaller ones being in all probability the same generation as those found at the Sault Ste. Marie earlier in the season.

Besides its enemies among the spawn-eaters, the herring has much the same class of enemies as those already enumerated for the white-fishes.

Of the parasites the most marked species is a *Bothriocephalus* found in the muscles of the dorsal region. They measure two or three inches in length and are found in masses between the intermuscular fasciæ of the back. The specimen in which the parasites were found was taken in Detroit River in the month of April, and though not observed after the month of June, it is certainly common earlier in the season, as the fishermen are familiar with the fact. A parasitic worm has also been seen in the intestine.

The external parasite of the white-fish, a *Lernæa*, was not seen attached to a single specimen of the lake-herring where hundreds were continually passing in the confined ponds of Detroit River, though they were seen to be very common on the white-fish. Nor were any specimens of the *Echinorhynchus* found in the intestines, though a white-fish is seldom examined without finding them numerous.

24.—THE LAKE-STURGEON, *Acipenser rubicundus*.

(24 a.) *Synonymy*.—*Acipenser rubicundus*, LESUEUR, Trans. Amer. Phil. Soc., (new series,) i, p. 388, pl. 12; RICHARDSON, Faun. Boreal. Amer., iii, p. 224; FITZINGER and HECKEL, Ann. Wien. Mus., i, p. 316; DEKAY,

Zool. N. Y. Fishes, iv, p. 344, pl. 58, fig. 191; STORER, Synopsis Fishes N. A., p. 248; THOMPSON, Hist. Vt., part 1, p. 149.

Acipenser ruthenus major.—FORSTER, Phil. Trans., lxiii, p. 149, [Young.]

Acipenser rupertianus.—RICHARDSON, Faun. Boreal. Amer. Add., p. 311, pl. 97, [Young;] STORER, Syn. Fishes N. Am., p. 249, [Young.]

Acipenser laevis.—AGASSIZ, Lake Superior, p. 267; DUMÉRIL, Hist. Nat. Poiss., ii, p. 151, pl. 17.

Acipenser carbonarius.—AGASSIZ, Lake Superior, p. 271, pl. 5, [Young;] DUMÉRIL, Hist. Nat. Poiss., ii, p. 111, [Young.]

Acipenser rhynchus.—AGASSIZ, Lake Superior, p. 276, [Young;] DUMÉRIL, Hist. Nat. Poiss., ii, p. 179.

Acipenser oxyrhynchus.—THOMPSON, Hist. Vt., part i, p. 149.

Acipenser maculosus.—GÜNTHER, [in part,] Cat. Fishes Brit. Mus. viii, p. 339, [Young;] DUMÉRIL, Hist. Nat. Poiss., ii, p. 114, [Young.]

Acipenser anthracinus.—DUMÉRIL, op. cit., p. 126, pl. 15, [Young.]

Acipenser megalaspis.—DUMÉRIL, op. cit., p. 135, [Young.]

Acipenser lamari.—DUMÉRIL, op. cit., p. 139, [Young.]

Acipenser kirtlandii.—DUMÉRIL, op. cit., p. 161.

Acipenser nertianus.—DUMÉRIL, op. cit., p. 162.

Acipenser buffalo.—DUMÉRIL, op. cit., p. 231, [Young.]

(24 b.) *Characters separating it from other American species*.—In comparisons with the limited number of specimens of other species that are available, the more prominent differences between this species and the others were found to be in the following characters:

In general form there is perhaps one American species, *A. oxyrhynchus*, more elongate. The mouth is large, compared with the species mentioned and with *A. brevirostris*. In the size of the area of naked skin around the eyes and nostrils, it agrees with *A. acutirostris*, and differs from the other American sturgeons, in which it is very perceptibly larger, apparently reaching its maximum in *A. transmontanus*.

A. oxyrhynchus, in the specimens at hand, is well distinguished from the lake sturgeons, as well as other American species, in the proximity of the frontal plates, usually merely separated by a naked strip of skin, the last-mentioned character very marked in the young specimens. In *A. rubicundus* and others, the ethmoid plate extends high up between the frontals, separating them entirely. Exceptions to this fact are very rare, the only one that has come under our observation being in a young specimen of *A. maculosus*, from the Ohio River.

There are no plates surrounding the anus, as in *A. oxyrhynchus* and *A. brevirostris*. In the fact of the presence of well developed shields posterior to dorsal fin, it is different from *A. transmontanus* and *A. medirostris*. The variations in the number of shields in the dorsal series, in a very large number of observations at the lake-fisheries, was found to be between 11 and 15, the number of 13 being found most frequently. In this, though a variable character, it is pretty definitely separated from the other species, except *A. transmontanus* and *A. brachyrhynchus*.

The variation in the lateral series was within the numbers thirty and thirty-nine, the most often-recurring number being thirty-four. In this character it is well separated from *A. oxyrhynchus*, *A. brevirostris*, *A. transmontanus*, *A. acutirostris*. The number in the ventral series was found to vary between eight and ten. From *A. maculosus*, of the Ohio River, a very constant character differing from *A. rubicundus* was observed in the longer blades of the keels on the shields, they being prolonged backward and the points or hooks directed posteriorly, while in the lake species the keels are more central and their points rise nearly vertically.

In the obsolescence of the plates, certain species of the old world are similar. Kirtland claims the same fact for the Ohio River sturgeon. In a specimen of *A. transmontanus*, in the National Museum, the same tendency is indicated, the plates of the body having become thin and wafer-like and no appearance of the keels remaining, though in younger specimens the keels are prominent and sharply hooked.

The skin throughout is covered with tooth-like points, and is unlike other American species in the minuteness of these interserial ossifications, except *A. transmontanus* and *A. medirostris*.

The snout in the adults is very much obtuse and rounded, and its cartilaginous extremity very little protected by plates. Its great reduction in length, with age, makes it an unreliable element in calculating the proportions of the body, and in the table of proportions it is, for this reason, not included in the measurements of the specimen; the proportions of parts to the length of the trunk being calculated with reference to the distance from the opercular opening to the end of the lateral series of plates, and the parts of the head to its length, are calculated with reference to a measurement from the orbit to the posterior edge of the opercular opening.

(24 c.) *Different characters in old and young sturgeons*.—The great number of species of sturgeons made by numerous authors has resulted not alone from basing them on characters of insufficient value, but from the great differences in the appearance of old and young specimens. These differences are in the snout, which is, in young specimens, long and slender, but which, by being absorbed or failing to grow as rapidly as the rest of the body, in the large sturgeons has a blunt and obtuse form; and in certain species, in the possession of large, well-developed shields in the younger ones, and their gradual disappearance as they mature and attain full size.

Allusion has been made by Dr. Kirtland to the fact of the disappearance of the shields in certain American species as the fish increased in size. In accordance with this view, he placed the names of several species of other naturalists as synonyms of *A. rubicundus*. This arrangement was accepted by Storer and introduced in his Synopsis of the Fishes of North America.

Günther refers to the tendency to variation in these characters in the common European sturgeon.

Duméril refers to the shortening of the snout and wearing away of the plates, but is not influenced by his knowledge of the fact in establishing species.

Among many hundreds of sturgeon of different sizes brought in from the nets and landed while we were visiting the fisheries of Lakes Michigan, Superior, Huron, and Erie, not a single specimen was seen, of a size of three feet or less, in which the five rows of shields were not developed and keeled; and if the young of the larger individuals are not represented in these, they are not taken by the seines, pound-nets, or gill-nets that gather in fishes from all parts of the lakes and streams.

Up to an average length of about twenty-five inches the shields increase somewhat in size; afterwards there is a gradual diminution by the wear of the keels and the absorption of the shield at the edges and base. The snout, too, from the thin, elongated point of the smaller individuals, is dwarfed into the short, obtuse anterior extremity of the larger ones.

Besides the examination of a large number at the fisheries with the object of determining the number of species, we have made a minute examination of twelve specimens, of from one foot three inches to five feet seven inches in length, from the lakes, with the following results: In specimens of fifteen inches and less in length the shields are distinct, large in proportion to the size of the fish, but crowded and imbricated; up to about twenty-five inches in length the shields increase somewhat in size and become less crowded. The shields of these smaller specimens have well-developed keels, terminating in a hook or spur, with a sharp point. In those a little larger the points are found dull and the hook disappearing. The keel, finally, is no longer apparent, leaving the white, worn mark of its base on the shields. The shields decrease in size from the edges; those just anterior to the ventrals are the first found missing; the ventral shields disappear entirely, and the posterior dorsal shields are next found missing, until a few of the anterior ones are barely distinguishable; even the callosities of the skin, showing the former position of the shields, become effaced, so that it is impossible to count the number of ventral or dorsal shields. The lateral series are the most persistent, and have never been found in our observation entirely effaced. In a description of a specimen from Lake Erie, Duméril gives the absence of the lateral shields as one of the characters. [Hist. Nat. Poiss., p. 151.]

This entire disappearance of the ventral shields is almost without exception in the full-grown specimens. Examination of hundreds of specimens at the fisheries of the Detroit River, at Sandusky, Ohio, where a very large quantity are taken, at Waukegan, Ill., Calumet, Ill., and the Lake Huron and Lake Superior fisheries, proved this fact beyond question, the only exceptions being the retention of a remnant of the

shields, like a small button, in a few mature specimens. The keels of the dorsal shields have been seen in a few individuals slightly prominent, where they had attained the length of about three feet, though these might not have been older than some of a smaller size who had not had so rapid a growth.

(24d.) *Description of adult specimen.*—Head from orbit to pectoral arch, .20 of length of trunk; an oblique line from orbit to posterior of supra-occipital plate, .19 of length of trunk.

The following proportions are given in one-hundredths of the distance from the orbit to the posterior edge of opercular opening, measured in a line with the axis of the body: Width of head at anterior nasal orifices, .34; width of head at orbits, .50; width of head at temporal plates, .61½; width of head at narrowest part of opercular openings, .54½.

P. 40; D. 35; A. 26; C. ¾.

Dorsal shields, 4 anterior ones apparent; lateral shields, 38, reduced to indistinct, narrow remnants; ventral shields, no trace remaining; shields separated and without keels.

Length, 5 feet 7 inches.

Locality, Ecorse, Mich., Detroit River.

(24e.) *Description of young specimen.*—A comparison of young specimens with mature ones shows the greatest differences to be the development of the shields, and the very much longer snout. The number of fin-rays, the series of shields, and the form and arrangement of the bones of the head, on all but the rostrum, correspond to the older specimens.

Head from orbit to pectoral arch, .17 of length of trunk; an oblique line from orbit to posterior of supra-occipital plate .16½ of length of trunk.

The proportions of the head are given in one-hundredths of the distance of the orbit to the pectoral arch. Width of head at anterior nasal orifices, .40; width of head at orbits, .59; width of head at temporals, .70; width of head at narrowest point of opercular openings, .66½.

P. 37; D. 37; A. 24; C. ¾.

Dorsal shields, 11; lateral shields, 34; ventral shields, 8 and 9; keels slightly worn.

Length, 28.2 inches.

Locality, Bayfield, Wis., Lake Superior.

Specimens from Lakes Erie, Huron, Michigan, and Superior have no more variation in characters than can be found among the specimens taken at a single fishing ground.

(24f.) *Size of mature fish.*—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.

(24g.) *Numbers.*—In numbers they will not compare favorably with any of the staple food-fishes. At Sandusky, Ohio, where they are more numerous than in any other locality, except, perhaps, Green Bay, Wis., there were about fourteen thousand mature sturgeons handled, weighing about seven hundred thousand pounds, obtained from about eighty-five pound-nets.

(24h.) *Economical value.*—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-shores they are in demand, and are prepared in the form of soups, (*bouillon.*) With a good, hearty out-door appetite, this is very palatable food, but too rich in the flavor of the oil of the fish for ordinary use. The flavor of 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 a salt-pickle and allowed to remain for some time. Nearly all the caviare is shipped to Europe while in the salted condition. [For full account of manufacture, see appendix; Account of Fisheries and Phoca hunting, &c.]

Mr. Schacht says they use from ten to eighteen thousand sturgeon a year, receiving during 1872 thirteen thousand eight hundred and eighty, averaging fifty pounds each. Before this firm began their work, the sturgeon taken by the nets were uselessly destroyed or sold by the wagon-load for a trifle, just as is the case in Green Bay, Wis., at the present time. The firm at Sandusky settled at that point only a few years ago, bringing with them but a small amount of money. They now own their curing-house, warehouse, and freezing-house, all neat, well-

arranged buildings for their purpose. A good substantial dock adjoins the buildings. They have interests in other profitable investments at Sandusky, and are generally well to do. The sturgeon has been the main part of their business, though they have smoked other fish for the market, principally the lake-herring. Out of a shameful waste of a large supply of food they have established a large and profitable industry.

The details of their success are reported because in the other parts of the lakes, excepting the vicinity of large cities, where they are generally marketable, the sturgeon are destroyed in the most wanton and useless manner, and there is the opportunity in Green Bay, Wis., for some one with skill and enterprise to succeed to an equal extent, and to utilize thousands of pounds of food that are wasted every year.

Visiting a firm in Chicago, who handled smoked sturgeon, I learned that their books contained orders for much more than they could supply, and they were willing to pay a round price for the article. The fishermen would, of course, be willing to sell the fresh sturgeon as they are taken out of the net, but think they cannot afford the trouble of smoking the quantity they capture in their own nets. The Sandusky firm are not net-owners, but purchase all their fish, and the same arrangement is necessary in this locality. Some of the Lake Michigan fishermen owning a small steam fishing-boat would be the best prepared for this work as they could gather up the catch of each day from a large number of nets and carry it to the curing-establishment. The sturgeon could be obtained for a mere nominal price, as the only care among the fishermen of the locality, during my visit in 1871, was to get rid of them to the best advantage. [This enterprise has been lately begun by a man well qualified to succeed.]

(24 i.) *Range of Sturgeon.*—The chosen range of the sturgeon is the shoaler waters of the lakes and their bays. They are very abundant among the islands at the western end of Lake Erie, in Green Bay of Lake Michigan, and at the southern end of this lake. Chaquamegon Bay of Lake Superior, near the Apostle Islands, has them in numbers. They are found in all localities in more or less abundance.

(24 j.) *Food.*—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.

(24 k.) *Habits in the spawning-season.*—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, Mich., 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, Mich., 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, Ill., July 1, of the year just referred to, a large list 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, Wis., 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 waters than in warm.

(24 l.) *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 numbers 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 future. A very large number are destroyed in this way, probably equaling or excelling 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 numbers 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-net, that the destruction of the sturgeon, asserted to be an extensive spawn-eater, more than compensated for the numbers of white-fish taken.

25.—AN IMPORTANT SPECIES.

There is another species of fish, the wall-eyed pike, *Stizostedion americana*, a knowledge of whose habits would be important to a proper conservation of the species, but its spawning season is in the spring and earlier than circumstances have permitted us to visit its localities.