APPENDIX.

I.—FISH COMMISSIONS.—AN HISTORICAL SKETCH.

DR. JOEL C. PARKER.

One of the first and most pertinent questions asked in this utilitarian age, of any investment, whether public or private, is: Will it pay? And of no subject of a public nature has this been asked with more pertinacity than of the establishment, endowment and continuance of the Fish Commissioners in the several states of our union and that of the general government.

It is a fair and honest question, and a sincere desire on the part of the commission of this state to answer it fairly and honestly is the object of this paper; and to do this, it seems quite to the point to review the reasons that first led to the establishment of such commissions; their success and failure so far, and to predicate from what has been done what may reasonably be expected for the future.

It is generally conceded that the first successful modern experiment in the artificial propagation of fish was made by Stephen Ludwig Jacobi at Hoenhausen, in Westphalia, in 1784, and was carried on successfully on the Jacobi estate for a period of more than eighty years; but the time had not yet come when public attention could be aroused to the gradual but sure decrease in the food supply furnished by the waters of the seas and rivers. Although these experiments were known among the more progressive nations throughout the world, yet nearly a hundred years elapsed before any particular attention was again called to this subject. At this time, 1842, an illiterate fisherman living among the mountain streams of the Vosges—Joseph Remy by name—re-discovered the fact that the eggs of the brook trout could be artificially fecundated and hatched, and in conjunction with a companion, Antoine Gehin, the work was carried on until it became publicly known.

This was the germ out of which has grown the extensive and important system of fish culture; for as soon as it was demonstrated that one variety of fish could be successfully increased many hundred fold, the question of why not others was sure to find an answer. Numerous experimentalists entered into the work, and with such marked success that at the end of four years the French government, recognizing its value as a great public benefit, established the first governmental station and inaugurated the plan of Fish Commissions. This was followed in the same year by Norway, by Finland in 1852, and by the United States in 1853, and since then nearly every government with any commercial fisheries interests have created commissions or in an equivalent way have encouraged and carried on some system of artificial fish propagation as a public benefit. In the United States the several states, recognizing the inability of the general government to carry on a work so vast unaided, and that to a large extent the benefit derived was local, those states having a large pecuniary interest in the growth and capture of the inhabitants of the waters of rivers, seas and lakes. instituted commissions, placing in their hands such sums of money for carrying forward the work as the legislators deemed best. These commissions have from time to time issued reports. These have shown how the money was expended and as far as possible the results obtained.

In 1871 the first proposition to establish a commission was put before the legislature of this state. It met with but little support, and many jokes were launched at its advocates. But in 1873 Hon. Eli R. Miller—who may well be called the father of the Michigan Fish Commission—introduced a bill and pushed it with so much earnestness and enthusiasm, enlisting in his cause, outside of the Legislature, Hon. Geo. H. Jerome, of Niles, and Rev. J. G. Portman, of Benton Harbor, who brought a good deal of enthusiasm and some practical knowledge to bear on the case, and through these efforts the bill passed and became a law. Governor Bagley appointed as commissioners Hon. Eli R. Miller, Hon. Geo. H. Jerome and Hon. George Clark, and the Legislature appropriated the sum of $15,012.50 to inaugurate the work. Since then the work has been carried forward by those having it in charge with that success and failure which must unavoidably attach to any enterprise in which there are many experiments to be tried and many obstacles, due to inexperience, to be overcome. One of the most difficult things that any commission has to deal with is the verification of some portions of their work, especially that into which the most time and money must be put, namely, the planting of fish in immense bodies of water, such as the salt and "unsalted" seas. The field is so vast and the plants so small, comparatively, that of a necessity a long time must elapse, and a careful gathering of statistics, to be as carefully collated and generalized, of the yearly catch of such fish as are propagated and planted, the increase in number and efficiency of all apparatus used in their capture, before any data can be formulated in which we can say we *know*, because it is a matter of mathematical demonstration.

That which sustains and upholds us, and gives us the earnest courage of our convictions, are certain forms of deductive reasoning drawn from observed facts, and a few isolated facts that bear very strongly upon the case. Our deductions are from these and similar premises. It has been stated, and our observations confirm the statement, that not more than one egg of each thousand from a parent whitefish is fertilized and hatched, while by artificial propagation 940 in each thousand are usually hatched. In each female fish there is an average of 25,000 ova, then from this one fish the average hatch will be 24,000 young fish, from each parent, artificially pro-

duced, against 25 in the natural way. It is perfectly plain, then, that the product of one fish artificially handled, is nearly equal to 1,000 fish left to natural methods.

From meagre reports collected, the amount of whitefish caught in 1885-86-87 was 13,572,370 pounds, an average of 4,524,723 pounds for each year. The average weight of each fish is two pounds; 2,262,061 would represent the *number* caught. Admitting that this is an adequate supply for the country, and if continued the supply would remain constant, then the number of female spawning fish necessary to maintain this supply naturally, would be 90,482, and by the artificial method, 100 would suffice. Admitting that by either method the young reach maturity, and the chances are equal, then as soon as it can be ascertained—if it ever can be—how many fish a given area of water will support, it will only be a question of arithmetic as to how many fish we must plant each year to keep up the supply, and just what it will cost to produce them. The most important factor, after all, and the one to which the least attention has been paid, is that of food for the fish we plant; probably the greatest failures made by the commissions are those depending upon a proper food supply. It was almost taken for granted. by all primitive fish culturists, that as all fish lived in water, therefore they would live and thrive in all waters; and so in the early days of fish commissions thousands of fish were planted in unsuitable waters, and failures followed as a matter of course. In this state considerable numbers of whitefish and lake trout were planted in the inland lakes, and with the possible exception of a few planted with whitefish, were blooming failures. The eel experiment was another brilliant generalization. It was well known that the eel lived and throve in the dull, muddy water of the east, and it was very reasonably supposed that if transported a little further west he would be just as prolific and toothsome as in the east; the failure in this case was not one of food, but one of reproduction. We did not know then as well as we do now, that it was the unvarying law of nature that the eel should go to the salt water to propagate his species, and therefore we brought several millions of eels and distributed through the state; they have grown to a large size, many of them, but have failed to furnish any "little ones."

The distribution of the California salmon has been another curious experiment. Planted in our brook-trout streams as "fry," they remained and throve until the second year, when they disappeared entirely. From those planted in this state a few have been captured in the great lakes, these had grown to several pounds weight. In eastern waters, where the conditions seemed as favorable as in the waters of the Pacific, no results were obtained, while on the other hand the eastern shad, transported to the west, has so reproduced and multiplied that specimens have been gathered from San Diego to Oregon, and his place among the food fishes of the west become a material and economical fact.

Of foreign fish introduced, the German carp has proved the most successful, and is to-day distributed and being successfully cultivated in nearly every state in the union. And so in experimenting, successes have more than balanced failures, and while many plans and theories are still tentative, or even questionable, still in its broadest generalization, fish propagation, as a great public benefit, has passed the experimental point, and become a fact of national importance.

2.—THE CANADIAN AND AMERICAN FISHERIES OF THE GREAT LAKES.

BY JOHN H. BISSELL.

One of the ways in which the Canadian treatment of the general subject of fisheries is valuable is the exact and useful knowledge which they obtain of the whole subject. This accurate knowledge of the fisheries is serviceable in many ways. For instance, it enables the Legislature to know its importance as a subject of legislation; it tallies from year to year the success or failure of the preservative measures; it points out distinctly the value of artificial propagation and the points at which natural sources of re-supply need re-inforcement by artificial and scientific methods. The Canadian reports show the total value of the fishery product of the Dominion, and also minutely the relative value of each item or variety of fish, as well as that for each province.

There is before me the Report on the Fisheries of Canada for the year 1883. On the first page is the statement that the product of 1883 was $134,100.64 more than for 1882 for the Dominion; the total valuation for 1883 being $16,958,192. Of course the greater part of this enormous production is of salt water fisheries, while the principal interest of dwellers along the great lakes is respecting the Canadian fresh-water fisheries—those of the province of Ontario. Before going into that, however, it will be interesting to look at the reports of 1884 and 1885, and compare the total production for those years with the total of 1882 and 1883. The figures are given as follows:

1882	$16,824,092 34
1883	16,958,192 98
1884	17,852,721 00
1885	17,722,973 18

There was a general increase for 1885 in all provinces except that of Nova Scotia, where there was a decrease of "nearly half a million in the item of mackerel alone."

Turning now to the province of Ontario we find the total value given for 1883 to be $1,027,032.88, an increase over 1882 of $201,575.86. The principal items in the order of their values are:

Salmon trout	$354,692 72
Whitefish	264,581 60
Herring and ciscos	97,070 00
Pickerel	82,096 38

The expenditure for "fishery service" for the entire Dominion for the year 1883 was no less than $114,673.76, and in 1884 was $116,531.66, of which the amounts for the province of Ontario were as follows:

Purpose.	1883.	1884.
Fishery officers, salaries and expenses	$13,602 00	$15,192 73
Fish-breeding	10,144 95	8,011 17
Total	$23,746 95	$23,203 90

The total expenditure for fish-breeding in the Dominion for 1883 was $25,776.87, and the amount for fishery officers was $62,341.43. The total value of the fish product of Ontario for 1884 was $1,133,724.26.

The number of men employed in this province as fishery officers in 1884 was 82, for a coast line no longer than that of the state of Michigan. This number of men, designated as "fishery officers," does not include the men employed in fish-breeding, but only those employed as inspectors, overseers, and wardens to enforce the fishery laws.

We desire to call particular attention to the figures for the year 1885, because that is the only year in which the Michigan fishery product has been accurately reported, and consequently the only season's fishing for which any reasonable comparison can be made between this state and the province of Ontario.

The total fish product of the province of Ontario for 1885 in value was $1,342,691.77, or a little over four and two-thirds cents per pound on the average.

	Pounds.
Whitefish	3,938,500
Trout	5,431,654
Herring	11,941,200
Muskallonge	565,400
Bass	636,397
Pickerel	1,757,494
Sturgeon	1,459,035
Pike	468,430
Other kinds, coarse fish and eels	2,578,908
Total	28,777,018

This statement includes 913,100 pounds of fish consumed at home by the fishermen and their families or by others, so as not to appear in the totals of the amount marketed.

During 1885 the expenditure for "fishery service" for the Dominion was $153,215.56; for fishery officers, $77,821.67; and for fish-breeding, $43,879.82.

For the province of Ontario, in 1885, there was expended—

For fishery officers, salaries and expenses	$17,135 98
For fish-breeding	8,690 15
Total	$25,826 13

It should be noticed that the figure $8,690.15 for fish breeding does not include the salary of the superintendent or office expenses. Further, it is for the maintenance of two fish-breeding establishments; one at Newcastle, for trout and salmon, and one at Sandwich for whitefish and pickerel. The state of Michigan maintains four establishments or hatcheries, the estimated cost of which was $9,476. On the basis of these figures, the output of young fish is about 20,000,000 in excess of the Canadian hatchery product, while the excess of expenditure is only about $800. It should also be noticed that the expenditure in Michigan for all purposes connected with the fisheries was, for 1885, but $12,000 (not including permanent improvements), against the Canadian expense for the same year, for fish-breeding and care of the fisheries, $25,826.13, as given above.

The force of this comparison will be more fully appreciated from the figures given below, which show the product of Michigan fisheries to be about equal to those of Ontario in weight; and if the values are computed at the same rate as the Canadian, the total value will be about the same.

In the seventh Michigan report (1886) the catch of 1885, as there estimated, is 26,381,875 pounds. Adding to the amount allowed by the Canadian report for home consumption, not reported, 913,100 pounds, we have, as the total to be estimated, 27,294,975 pounds.

This, at the rate allowed in the Michigan report (three cents per pound), is equal to $818,849.25. But if taken as the Canadian product is, not by a general average, but at their figures for each species, the result will be as follows:

Michigan product, 1885.

Kind.	Pounds.	Price.	Value.
		Cents.	
Whitefish	9,985,015	7 1-5	$718,821 08
Trout	5,469,912	7½	410,235 90
Herring	5,249,384	2 2-5	126,510 15
Pickerel, bass, and sturgeon	1,530,161	5	76,508 05
Other kinds	5,060,603	3	151,818 09
Total	27,294,975	5 1-10	$1,483,893 27

Product of Michigan and Ontario, 1885.

	Pounds.	Value.
Michigan	27,294,975	$1,483,893 27
Ontario	28,777,018	1,342,691 77
Difference	1,482,043	$141,201 50

The excess of the Ontario product over that of Michigan is thus seen to be 1,482,043 pounds, while the value of the Michigan product is $141,201.50 above that of Ontario. This result is accounted for by the larger production of whitefish in Michigan waters, as shown by the following comparison:

	Pounds.	Value.
Michigan	9,985,015	$718,821 08
Ontario	3,938,500	282,950 00
	6,046,515	$435,871 08

Or if the Michigan product is figured at what is probably the exact Ontario average price, as their fish run, that is $4\frac{2}{3}$ cents per pound, it is $1,271,945.83.

But, in view of the larger production of whitefish in the Michigan catch, it does not appear that the above comparison is at all unfair.

Taking the products of the two states as about equal in quantity and value, there is a very noticeable difference in the amounts expended by each in the care and conservation of this industry, as shown above. The coast line of each state is of the same length, about 2,000 miles.

Detroit, Mich., March, 1887.

3.—SOME EXPERIMENTS WITH THE FRY OF WHITEFISH.

BY DR. J. C. PARKER.

The question as to whether the young of the whitefish would find food and live when planted out of season much earlier than at the time at which they usually mature had been one of much discussion amongst those interested in fish-culture in Michigan, it being generally thought that while the lakes were filled with ice that the temperature of the water would be so low that there would be no organisms upon which the young fish could feed, and, consequently, starvation would ensue. To test this question Superintendent Marks directed the overseer, Mr. A. W. Marks, of Petoskey Station, of the Michigan Fish Commission, to institute certain experiments and to report the same to the board. The report is as follows:

On March 1, 1887, a small screen or crate made of wood and wire netting, three feet long and four and a half in diameter, in the form of a cylinder, was placed through the ice in Little Traverse Bay, in 100 feet of water, and 10,000 whitefish placed in the crate and lowered to the bottom with a strong rope. On March 5 the crate was raised and the young fry were nearly all alive, only six dead ones found. On March 10 the crate was raised again and twelve dead fish were found. The fry had turned to a light brown, the yolk sac was nearly absorbed and the fish seemed in good health. On March 12 the crate was again raised and some of the fry taken out and brought home; also a jug of water from the bottom and another from the top was taken. One drop of this was placed under a strong glass and life could be seen very plentiful. The stomach of one of the small fish and a drop of the water was placed under the glass and it was found to be full of diatoms and vegetable matter. The diatoms seemed to be working around the small pieces of vegetable matter; the sac of the fry had been absorbed and they were feeding upon the vegetable matter and the animalcule. On March 14 the crates were again lifted, and the fish seemed to be doing well in about the same condition as on the 12th. About 100 dead fish were found on the 14th. The crate was lifted on the 18th; no change could be seen. On the 24th the crate was again lifted, and some of the young had turned to a light green, the color of a herring a year old. On March 24 another crate was sunk, containing 5,000 fry. This was lifted on the 18th, and two dead fish were found in the crate. At this date the first crate sunk contained fish forty-five days old that had been under the ice twenty-eight days. About the last of March the ice moved out of the bay, thus preventing any further systematic observations. Later on the submerged crates were recovered, but the wire screens had become filled with sediment, caused by the roiling of the water consequent upon the breaking up of the ice, and no live fish were found in them This closed the experiments for that year, and circumstances prevented their continuance this spring.

Grand Rapids, Mich.

4.—SOME OBSERVATIONS ON THE BLACK BASS.

PAPER READ BY MR. C. F. HOLT AT THE 17TH ANNUAL MEETING OF THE AMERICAN FISHERIES SOCIETY.

Having resided for the past 35 years on the bank of the Thornapple river, a favorite resort for that king of Michigan game fish, the small-mouthed black bass, I have had ample opportunity for studying their habits, and for the past few years have given the matter considerable attention.

They leave their winter quarters, usually under heaps of drift-wood or in hollow, sunken logs, about the middle of April, and in a short time repair to their spawning grounds. I am quite sure that they pass the winter in hollow, sunken logs whenever they can, for, about the 1st of April, 1885, while removing some drift-wood from the river, we took out one hollow log that contained 18 small-mouth black bass, weighing from two to three pounds each; and again this year, at about the same time, I found six more under the same conditions. The spawning season here begins the last week in April. The first bed seen in 1885 was on April 28; in 1886, April 24; and in 1887 and 1888, April 26. The places selected are in nearly still water, near the shore, and in water from one to two feet in depth.

The beds are circular in form, from 18 inches to three feet in diameter, and are formed by cleaning from the bottom all sediment, sand, etc., leaving a bed of clean pebbles. This is the joint work of both male and female fish. The bed having been prepared, the female then moves slowly over it, depositing her ova, and the male impregnates them as fast as laid. The eggs, which are very small, are glued fast to the pebbles. The impregnation is almost absolutely perfect. In the past three years I have examined a large number of beds by carefully removing one or more of the pebbles covered with eggs, and examining them with a microscope, and have never yet found more than one per cent. of unimpregnated eggs.

After the eggs are impregnated the male leaves to the female the whole care of the eggs and the young brood. She now passes constantly backwards and forwards over the bed, the motion of her fin and tail keeping the eggs clean, which the fact of their being glued fast permits her to do without washing them away. The following incident will illustrate the necessity for this constant care and attention on the part of the female, as well as point a moral, and furnish an illustration of how the greatest possible increase of this fish may be brought about: One evening in the spring of 1886 I noticed a "jack light" coming down the river, and I felt certain that some of my pets would have to suffer. I had endeavored to protect them as much as possible by requesting such neighbors as I could reach to respect my wishes and to avoid the beds that I had under observation. Nearly all were willing to do so, but this time one of them made a mistake, as I expected they might, and when I went out in the morning the mother fish was gone. I thought I would secure the young fish (they were just hatched) and take them to the house and "bring them up by hand." So. putting on my wading boots, I walked out to the bed, and there I found, not the young fry, but three or four crayfish and some minnows, which had evidently devoured every fish on the bed. At another time, under similar circumstances, except that the eggs were not hatched, the crayfish had destroyed all the eggs. I took up every pebble without finding a single one.

The eggs are hatched in from five to ten days, according to the temperature of the water. When first hatched, the young fish are transparent and so small as to be invisible to the naked eye. They have a much larger umbilical sac than the young brook trout in proportion to the size of the body. At first they are unable to swim or even move themselves from the bottom, but in from two to six weeks they begin to rise and swim, although they are from one to two months old before the sac wholly disappears and they become perfectly developed fish.

After the fish are hatched the mother seldom passes over the bed, as in their then helpless state the motion of her fins would scatter them; but instead she now swims in circles around it, driving away all intruders, such as minnows, crayfish, etc. After the young begin to swim she enlarges the circle until it becomes from ten to fifteen feet in diameter; she then gradually drives them towards the shore into shallow water, where she keeps them inside of a half circle, the shore forming the other side. From this half circle all of their natural enemies are carefully excluded, and the fish are allowed to develop. After that is done she scatters them along the shore among the weeds and grass, where, if pursued, they can find hiding places. Then, and only then, does she leave them to care for themselves. They are now from one-half to three-fourths of an inch in length, black in color, and very lively, darting out of their hiding places and seizing their prey as readily as the elder fish, and by the first of October following will be two inches in length.

I should estimate the average number of eggs in the beds at 4,000. Owing to the fact that some of the beds observed were near the mouths of cold spring brooks, where the temperature of the water in the river was much lower than where other beds were located, will account in a great measure, in my opinion, for the variation in the time taken for hatching the eggs and the development of the young fish; as in some seasons and in some locations I have found the young fish developed or weaned in one month from the time that the ova were deposited, and at other times two months were required for the same purpose.

I have been unable to procure both male and female fish at the proper time to try artificial impregnation, but have repeatedly taken part of the ova from the bed as soon as impregnated and hatched them in dishes, and have kept them there until fully developed. I am of the opinion that very little can be done in the way of artificial impregnation or hatching, as nature has done for the black bass all that could be done.

All that the fish-culturist needs to do is to stock all suitable waters with them, where they do not now exist, and then protect them during the spawning season.

5.—CO-OPERATION IN FISH-CULTURE.

BY JOHN H. BISSELL, OF THE MICHIGAN FISH COMMISSION.

Within the limits properly allowed for a paper in a meeting like this, it is scarcely possible to do more than sketch or outline a subject such as I have chosen. I am consoled, however, with the reflection that the manner and style will be passed with indulgence if only there be some merit in the subjects presented for consideration, or at least good faith on the part of the reader.

I think it is generally agreed, that fish-culture has passed its purely experimental stage. It is in fact fast becoming recognized as a practical art, and an established department of civil government, its definitely ascertained results, which are now unquestioned, fully warranting the recognition it has received from the states and the United States. Having so attained to the period when it is capable of being made a useful factor in the economy of every civilized state, the persons charged with the public duty of administering its affairs and evoking useful results from its prosecution ought ever to be looking for reasonable and practical ways to secure it the highest degree of efficiency. The United States Commission with a new and broader organic law recently adopted and put in operation, with its departments of work newly recast and systematized, and under most zealous and competent guidance, is prepared now to apply in the solution of some economic problems, the many lessons of experiment and scientific observation, gathered and stored up in the past. The states which have been dealing practically with the fishery question in the last ten years have made good progress towards reliable and permanent methods of fish-culture, and now at length are able to bring forward some definite and tangible proof concerning its results.

Fish-culture, when appreciated and invoked in both its branches, artificial propagation and legal regulation, has demonstrated its ability to restore exhausted fisheries. Of that there is no need of citing evidence to this audience. The next forward movement toward the realization of the great promises of the practical Art of Fish-culture, in this country is, I believe, to be the working out of a just and comprehensive system of regulation of fishing as an industry, and as a recreation. A notable feature of this movement will be the attainment of more substantial coöperation amongst the organized bodies existing for its prosecution under the state and federal government.

I have in mind two principal topics: 1. Coöperation between the United States Commission of Fish and Fisheries and the several State Fish Commissions; and, 2. The limited coöperation possible between the commissions of neighboring states, or between states having similar fishery interests. I am not unaware of the fact that the United States Fish Commission has heretofore coöperated with the state commissions. But I wish to call attention to the fact that such coöperation can be carried out on broader lines with advantage to all concerned.

You are all as familiar—perhaps many of you more so, than I—with the organizations employed in prosecuting fish-cultural work in this country, so that no detailed account of them is necessary. Here is the United States Fish Commission with men, with means, with appliances and with scientific knowledge, and while doing the same kinds of work that various state commissions are doing, yet doing much more than any single state organization. Here are the state commissions each prosecuting the particular kinds of work required by local conditions under which in the different states fish-culture is being carried on. At the points where these different organizations have work common to each, why may there not be cordial and effective co-operation? Not merely the negative, of not interfering with each other, but the positive working together to economize expenditures and effort, and thus increase general and permanent results.

Bordering the great lakes are six states having a population of about fourteen millions of people. The fisheries of these great lakes, as their product enters into the general commerce of the country, cannot be regarded as the concern of the six states—they are of national importance. If the fish captured in these lakes were consumed along their shores I grant that the states would have no special claim upon the general government for taking part in maintaining such fisheries, or helping in any way to their re-establishment. This was the condition of affairs once; but with the modern facilities of rapid communication and improved methods of transportation, their product is marketed all over the country, and for that reason the states bordering the great lakes have, in my judgment, as good a right to assistance from the general government, in the directions I shall presently mention, as the fisheries of the Atlantic and Pacific Oceans. Our lake fisheries are not to be compared in extent and value to those of the seas, but it is a difference in degree not in kind. The United States is doing a most necessary work in the investigation and promotion of the Atlantic fisheries, is preparing to investigate more thoroughly, and help develop the fisheries of the Pacific; it has done the country an invaluable service in examining and illustrating the seal and other fisheries in connection with the last general census; for all of which it has earned the confidence and commendation of the country. Why should not a similar service be performed by it in co-operation with the states bordering the great lakes in making an exhaustive survey and examination of the fisheries from Duluth to the St. Lawrence river? "The reward of having wrought well is to have more work to do." If the commission has not the equipment in steamers, the work already in hand probably requiring them all, why not borrow one or more of the revenue cutters that are lounging up and down the lakes? I may be doing that branch of the service an injustice, but I never have heard within ten years of those vessels doing anything more useful than cruise on a sort of dress-parade between Buffalo and Chicago.

If a revenue cutter could not be spared, then why not borrow from the Navy Department a despatch-boat, or some of the many steamers not suitable for modern naval warfare, and have her fitted out for this service. To do what? To be manned with the necessary crew, under command of an officer not above such service, placed under the direction of the United States Fish Commission, supplied by him with one or more naturalists, and one or more men competent to study and report upon the conditions, capacities and needs of the industrial fisheries, supplied with drags, sounding appliances, proper thermometers, duplicate charts of the lakes, and complete fishing apparatus. Upon the charts could be marked spawning-beds, seining grounds, the lines of inshore and outside fishing, abandoned fishing grounds, the lines where certain kinds of fish are most plentiful or scarce, the pound-net fishing stations and the like. With such an equipment it would be practicable to make a complete survey of the fishing, feeding and spawning grounds of the great lakes; exhaustive scientific observations and collections of the fauna; a census of the fishing industry, its methods, its product, its habits; in fact, a history that would, by its manifold and exact observations of the present condition and requirements of the industry and its possibilities, lead conclusively to a knowledge of the causes of its decadence, and what is necessary to be done for its restoration and permanent maintenance. Is it worth the expenditure? I think I can answer without hesitation for Michigan waters. I had occasion in 1886 to examine the history of Michigan fisheries, and was led to the conclusion, after careful examinations and comparisons of such statistics as are obtainable, that if our waters had been as productive in 1885 as they were in 1859, with the effectiveness of apparatus and extent of operations in the former year, the money value of the products of Michigan waters in 1885 would have been not less than fifteen millions of dollars, instead of about one and one-half millions. In 1887 I compared the product of the Michigan fisheries for the year 1885 with those of the Province of Ontario, and found that the money value of the former, if computed upon the same basis as that employed by the Canadian Department of Marine and Fisheries, exceeded that of the Province by more than $100,000.

The states bordering the great lakes having an immediate interest to be subserved by such an examination, as the work is being prosecuted in their waters, should co-operate by furnishing a crew of three or four men to assist in gathering statistics and other information, which would be of great value to the State Fish Commissions in illustrating to the Legislatures the kinds of regulations required to restrain wasteful fishing, which has gone so far towards depleting the waters, as well as the kind and extent of operations to restore productiveness of the waters. They might also direct or assist in the fishing operations of the expedition. Such an examination would also demonstrate the exact extent to which artificial propagation of whitefish benefited the fisheries, and indicate what points along the lakes required attention in order to the more even distribution of future supplies. The information so gathered would help, by furnishing the required data, towards another and most important feature in the regulation of the fisheries of the great lakes, namely, the licensing of fishing as an industry. In alluding thus briefly to this subject there is not time to more than call attention to the fact that a fair system of licensing would in time defray all or the larger part of the expenses of keeping up the supplies of fish when the waters were once well stocked, as well as such part of the cost of enforcing the laws as the state would be called on to pay. There are several minor ways in which co-operation can be advantageously adopted, but not of sufficient importance to be enumerated here. They are being employed more or less, and are familiar to you all.

For many years the U. S. Commission has thus co-operated with two or three of the New England States in procuring salmon and Schoodic salmon eggs, on terms, I believe, equitable and satisfactory to all parties, and with most excellent results.

Another direction in which co-operation can, I believe, be advantageously employed is in a thorough examination of interior lakes. By interior, or inland, lakes the dwellers along the great lakes are wont to distinguish the smaller bodies of water wholly within the boundaries of the several states. In Michigan, the numbers, size, and natural conditions of the inland lakes make them a considerable part of the waters we are called upon to care for. In the earlier days of this work these lakes were planted with various kinds of fishes, not with any special reference to their adaptability to the fish planted, but because the commission had fish for that purpose, and in a general way the people in the vicinity of the lakes wanted fish. I do not say this with the design of casting any reflection upon the authorities of those days. The promiscuous planting of fish was then perfectly natural; and our experience is based largely upon their mistakes as it is still more largely upon the notable success of so many of their experiments. As the years went by a very natural curiosity arose amongst citizens and fishery authorities to know what had been the result of those plants. Had all failed? If so, why? If the fish planted had not lived and prospered, would no others live in those waters? And, finally, the question formulated itself, are these waters suitable for any fish? If so, what kinds? There was but one way to answer these questions, and that was to go and find out. And so we went (by proxy). In 1885 in a desultory kind of a way the work of examining the lakes was begun. In 1886 a proper crew was organized, consisting of three men, one being in charge. They were provided with a gang of gill-nets having meshes of four different sizes, thermometers, a small drag or trawl, sounding lines, fishing tackle, blank reports with printed instructions, and a complete camping outfit. And so with fairly good and practical results the lakes of three counties on the southern border of the state were examined and reported on. For a short time towards the end of summer a second crew was sent out to examine some places where there were special reasons for knowing the contents and capabilities of several lakes. In 1887 further improvements were made in the outfit, and the crew increased to four. The addition of one man secured more expeditious work. The result of these examinations give the Michigan Commission in permanent and convenient form, not only the exact, but the essential facts about the lakes in eight counties of this state. The size, depth, character of bottom, quality of water, temperature, inhabitants, kinds and quantities of food; in a word what fish are there, and the knowledge of what can and ought to be there in order to obtain the greatest productiveness of the given waters.

One characteristic these examinations have lacked. They afford an opportunity for scientific investigation, which would add materially to their practical utility, and which would certainly make them more complete from all points of view. We have not the means to supply that want. The United States Fish Commission has the means and the men. We are discussing with the commissioner, and the head of the Department of Scientific Research of the United States Fish Commission, a practical method of co-operation in carrying on further examinations of Michigan lakes. Here is a field well worth cultivating. If fish-culturists are to do anything for the interior lakes they must know as well as possible the conditions under which their efforts must be tried. There are six or seven northern states besides Michigan, of which I have some knowledge, where such efforts ought to be made.

And while the lakes are being examined, why not the streams and rivers? Our experience has proved that that there are hundreds of spring brooks in this state suitable for the growth of speckled trout where that fish was not native. A systematic examination of all streams would in this state within a few years secure the planting of trout only in waters entirely adapted in temperature and good supply to trout. It would in my judgment also result in our being able to establish black bass in miles of water suitable for this admirable game and food fish where now they are unknown. Definite and comprehensive knowledge of the rivers and streams of the state, put into the same permanent and accessible form as the reports Michigan is getting of the lakes, is of importance just as the work on the lakes is.

Secondly, what co-operation can there be between State Fish Commissions? The most obvious points for co-operation between states, are where they border the same waters, as on the great lakes, or have a common boundary on a river,—as the Ohio, Mississippi, or Missouri. And here we must touch upon the regulation of fisheries, a subject pregnant with difficulties. For the states bordering the great lakes, a uniform system for every mile of the great waters ought to be established. Not necessarily identical enactments; for the waters of a single state, like Michigan, require a diversity in regulations to make complete for all its waters the operation of a general system. The objects to be sought by each state are the same, the means to reach these objects will necessarily be somewhat modified by local conditions. From our own experience, I assume that it is a difficult thing to secure the passage of suitable laws by the State Legislatures for the preservation of industrial fisheries. We have no difficulty in obtaining fairly good laws for the protection of game fish; but we have tried in vain thus far to persuade the Legislature of this state to do for the fisheries of the great lakes what must be apparent to any man of common sense, who gives the subject any attention, is essential to preserve them.

I think the common judgment of men, who are entirely disinterested but careful observers of the past and present condition of our fisheries, accords with that which is always expressed by the most intelligent and candid of practical fishermen and fish dealers, to the effect that our laws should cover three vital points:

1st. To regulate the size of the meshes of nets, the times and places of fishing.

2d. The market size of the various valuable kinds of fish.

3d. The employment and authorization of competent state officers to enforce the regulations and inspect the products being marketed; and there should be confided to the chief officer discretionary power to suspend, within prescribed limits, the regulation respecting the apparatus, when such suspension will not result in the destruction of immature fish, and may be an advantage to the fishermen.

Regulations should be as general, as exact and as simple as is compatible with efficiency, in order that they may not be oppressive or obscure. Of course, each state must enact its own laws. Each state has exclusive jurisdiction of its waters to its boundary line; this on the great lakes is a matter of great importance. It has many times been suggested by persons who had not examined thoroughly the question of jurisdiction, that Congress could better provide for the regulation of the fisheries of the great lakes, because these waters bordered so many different states. This question has been settled once for all by the Supreme Court of the United States, so that whatever of advantage federal legislation on this subject may seem to offer, it is a legal and constitutional impossibility, and must be dismissed. The states must do all there is to be done, and do it in their own several ways. Thus far it has been badly done,—or to speak more accurately, has not been done at all. Can there be any co-operation between the states to remedy this evil? There ought to be, is plain. And the fact of its recognized necessity ought to bring about, eventually, an affirmative answer. The force of a substantial and efficient example is the only constraint that can be brought to bear. When any one of the states bordering the great lakes will enact laws that are effective, its example will be followed.

Full and candid discussion between the fishery officers of the different states will be useful, and ought to be employed more frequently than in the past, for the purpose of harmonizing the views of all. By fishery officers I do not mean alone the fish commissioners, but include the wardens or officers employed to enforce the laws, by whatever names they may be known. And I believe that good results might be obtained from conferences between the fishery committees of the Legislatures of Michigan and Ohio, and Michigan and Wisconsin, and Ohio, Pennsylvania and New York. At least this is worth consideration.

A step in the right direction was taken by Michigan, in 1887, in the passage of an act for the appointment of a Game and Fish Warden. The act was not as broad nor the powers as extensive as the commissioners urged upon the Legislature; but it was one point gained. The thorough, consistent and intelligent course pursued by the gentleman selected by the Governor as the state warden will go far towards securing at another session of our Legislature the required improvements in the law, as it has already demonstrated the important advantages of the proper enforcement of such laws as we have. Wisconsin took the lead in this class of legislation, but from all that I have learned of its operation, I judge that the statute needs amendments in some important points to make it effective. Ohio, too, has started in the right direction. This is all encouraging, because in each case it has been a movement in the right direction.

The fisheries, in my judgment, have reached a point where no half-measure will answer. What is needed is to look the necessities of the case squarely in the face and provide wholesome and sufficient remedies, that will put a stop to the destruction and marketing of immature fish of all valuable kinds; and while it gives nature a chance to help repair the mischief already done, will likewise help to secure to the states the benefits of the artificial propagation and planting.

A third suggestion in the line of coöperation that I think worthy of discussion is between the fish commissions and the educational institutions of the state—as for instance, with the instructors in natural history in the State University, or the Agricultural College. There are many ways in

which the two could aid each other. The University or Agricultural College or both, might furnish the naturalists to accompany a crew of fish commis sion men in examining interior lakes and streams. They might do a notabl service by furnishing a naturalist, who is expert with the microscope, to be pres ent with our crews employed in gathering ova of different fishes; and by a critical study of ova and milt during the spawning time, instruct the men as to the appearance of the perfectly matured male and female properties, so as to bring such operations still nearer to perfection. At the same time, facts so acquired might be an actual and useful contribution to scientific knowledge. I am indebted to Mr. Marks, the Michigan Superintendent, for this proposal to improve the already good results attained in artificial fertilization.

Detroit, May 16, 1888.

6.—NOTES ON THE FOOD OF THE FISHES OF THE MISSISSIPPI VALLEY.

BY PROF. S. A. FORBES.

There is a kind of insect in the South, called the agricultural ant, which is extremely fond of the seeds of certain grasses growing there spontaneously among the many species which make the prairie sod. Naturally the agricultural methods of this ant are of a very primitive sort, and even fall below those of the native Indian. Besides collecting, wherever it can find them, the fallen seeds of many grasses and other plants, and storing these in its burrows, it also clears completely an area from six to twelve feet wide around its nest, and here either sows or permits to grow only one or two of the common grasses of whose seeds it is especially fond, harvesting the product and storing it for future use. It has not learned to cultivate the soil, or to introduce exotic plants of larger yield and better quality than those native to the sod, but it has advanced so far as to destroy on a little tract the competitors of the plants which bear its favorite food, and thus secures a large and more convenient supply than would grow spontaneously. I mention this little ant because its agriculture seems to me to illustrate very well the aquaculture practiced by mankind at the present time. As this little insect collects the seeds of weeds wherever they happen to grow, so we fish the streams for whatever they happen to contain; and as it clears its little farm around its burrow, so we make our little fish ponds, seine out the worthless and destructive fishes, the snakes, frogs, and turtles, and throw the better species back to increase for our benefit. In two things our aquaculture is in advance of the agriculture of the ants,—we have successfully introduced two or three foreign species, and we have learned to take measures to maintain the fish supply wherever it has suffered from the effects of overpopulation. The first of these measures the ants have not thought of, and the second they probably do not need, because their numbers do not overrun their food supply. I believe it will pay us to inquire whether we can hope to get beyond this ant stage of aquaculture, and whether we may not learn to do at least as much to increase and improve the product of the waters of the country as the wild Indian did to cultivate the soil.

At present, four things are done, in general: First, we attempt to maintain or restore the relative numbers of our valuable aquatic animals—fish especially—defending the population of our waters against the evils growing out of civilized settlements. This is like trying to restore the native growth of trees and grasses to the surfaces deadened by travel and building, and by careless or unskillful usage. Second, we try to increase the relative numbers of the most valuable of our native aquatic animals above the limit fixed originally by nature. This is as if we should collect and plant the nuts and acorns in the woods, and gather and sow abroad the seeds of the most valuable native grasses, in the hope that this artificial aid might enable our favorites to surpass their rivals. Third, we have aimed to introduce foreign with our native species in our natural waters. This is too much like sowing quantities of apple seeds and wheat and corn broadcast in the woods and on the prairies in the hope that if we use seed enough the plants we seek to introduce will crowd out the native vegetation. And, finally, we do, on a small scale, partly imitate actual agriculture by clearing or forming little patches of water here and there, and planting in them an exotic fish, protecting it from the competition of the native species. Here we approach the agricultural practice of the native Indian, who partly cleared his little patches in the river bottoms and planted and harvested the exotic corn and beans and pumpkins.

But it will not do to push this parallel too far. There are some things possible in agriculture which the aquaculturist cannot do. We cannot plow and till our lakes and rivers as the farmer does the prairie sod, ruthlessly exterminating all the native forms of life in order to substitute other sorts more useful to him. And even where we clear a little lake or start a pond, stocking it with carp or croppie, we cannot keep out the frogs and bullheads by any artificial tillage, as the farmer can the weeds. We are compelled, in other words, to work for improvement in the midst of things as they are. Not being able to destroy the native population of our waters, we have to take it into account and then make our adjustments to it. And right here, it has long seemed to me, is where the work is most needed. If we cannot get rid of the natural order we certainly need to understand it. If we cannot destroy the native population, but must live and work with and through it, we certainly ought to know what it is like and what we can do with it; what we can do in spite of it, and what we cannot do because of it. It is because I have worked out some parts of an answer to these questions that I have ventured to appear here to-day, in a society of fish-culturists. If fish-culture is merely the culture of fishes, then I can have little or nothing to say, because I never raised a fish in my life; but if a scientific and rational fish-culture must finally merge in the broader science and art of aquaculture; if we must study to understand and improve the system of aquatic life into the midst of which we thrust our little fishes,—then I may perhaps claim some share in your deliberations.

What I have to report to-day is chiefly an answer to the question: What do our native fishes eat? This is only a single item of what we really need to know, and yet perhaps a larger one than might at first be supposed. Although fishes are the dominant class in every fairly permanent body of fresh water, they have no great variety of interests or occupations; but except for the relatively brief intervals devoted to their simple office of reproduction, they do little but to search for food and to eat, and avoid being eaten in turn; consequently, if we seek to measure or estimate their function in the general system of life in any region or locality, we are limited chiefly to their food relations, immediate and remote.

Among the purely practical results to be anticipated from such a study, are a more accurate knowledge of the conditions favorable to the growth and multiplication of the more important species; the ability to judge intelligently of the fitness of any body of water to sustain a greater number or a more profitable assemblage of fishes than those occurring there spontaneously; guidance as to the new elements of food and circumstance which it will be necessary to supply to insure the successful introduction into any lake or stream of a fish not native there; and a clear recognition of the fact that intelligent fish-culture must take into account the necessities of the species whose increase is desired, through all ages and all stages of their growth, at every season of the year, and under all varieties of condition likely to arise.

We should derive, in short, from these and similar researches, a body of full, precise, and significant knowledge to take the place of the guess-work and empiricism upon which we must otherwise depend as the basis of our efforts to maintain and increase the supply of food and the incitement to healthful recreation afforded by the waters of the country.

As a contribution to the general subject, I present herewith a summary account of the food of twelve hundred and fifteen fishes, obtained from the waters of the state of Illinois at intervals from 1876 to 1887, and in various months from April to November. These fishes belonged to eighty-seven species of sixty-three genera and twenty-five families. They were taken from waters of every description, ranging from Lake Michigan to weedy, stagnant ponds and temporary pools, and from the Mississippi and Ohio rivers to the muddy prairie creeks, and the rocky rivulets of the hilly portions of the state. Nine hundred and fourteen of the examples studied were practically adult, so far as the purposes of this investigation are concerned, the remaining three hundred and one being young, in the first stage of their food and feeding habits. More than half these young belonged to a single species—the common lake whitefish—but the remainder were well distributed.

I have arranged the matter under the following general heads: (1) a general account of the food of the most important species and families of our native adult fishes; (2) a brief account of the food of the young; and (3) a summary statement of the food, so made as to exhibit (*a*) the kinds and relative importance of the principal competitions among fishes, and (*b*) the relative value to the principal species of fishes of the major elements of their food.

First, then, I will attempt to give you very briefly, and in the most general way, the facts relating to the food of the most important fishes, those which I think most likely to interest you as fish-culturists, taking the species in their zoölogical order rather than in the order of their economic importance.

FOOD OF ADULTS.

The abundant white perch or sheephead of the larger rivers and lakes, now commonly marketed, I find feeding, when full grown, almost exclusively upon the bivalve mollusks known in the west as clams, whose heavy shells this fish is enabled to crush and grind by a special apparatus in the throat. The shells are swallowed with the bodies and pass, in part at least, through the intestine. Half-grown specimens feed in much larger ratio upon aquatic insects, especially the larvæ of May flies, but take likewise the smaller mollusks with spiral shells, commonly known as water snails, the food in my examples being about equally divided between these two elements. The youngest specimens feed, like the young of fishes in general, upon the smallest of the crustacea.

The common perch or "ring perch," excessively abundant throughout the northern part of the country, varies in food according to the waters it inhabits, those in the great lakes feeding almost wholly upon small fishes (especially of the minnow family), and upon crayfishes—five or six times as many of the former as of the latter. River specimens, however, eat few fishes, but they find nearly half their food among the crustacea, partly crayfishes, but chiefly the smaller kinds, known to zoölogists as amphipods and isopods, and in common speech as water-lice and brook shrimps. Aquatic insect larvæ, especially those of day-flies, and small spiral-shelled mollusks are eaten in about equal ratio.

The two pike-perch or "wall-eyed pike," are exclusively piscivorous, if we may judge from twenty-six specimens whose food I studied. More than a fourth of the fishes taken consisted of the spiny-finned species, including eight per cent. of catfishes, but nearly half were the common gizzard shad.

We shall find accumulating evidence that this shad, not used with us for food, is, notwithstanding, one of the most valuable fishes in our streams. Nevertheless, not the slightest attention is paid to its preservation, much less to its encouragement. The fishermen commonly regard these fishes as a mere nuisance, and leave them to die on the bank by hundreds, rather than take the trouble to return them to the water. They are a very delicate species, and are easily killed by rough handling in the seine, but the majority of those captured might be saved with a little care.

Their abundance as compared with some other species in our rivers might seem to indicate that they are common enough as it is. Few realize, however, the number of fishes needed to feed a pike-perch to maturity. Two or three items from my notes will furnish the basis for an intelligent estimate.

From the stomach of a pike-perch caught in Peoria lake, October 27, 1878, I took ten well-preserved specimens of gizzard shad, each from three to four inches long; and from another I took seven of the same species, none under four inches in length. As the gizzard is a very thin, high fish, with a serrate belly, these were as large as a pike-perch can well swallow; and we may safely suppose that not less than five of this shad would make a full meal for that fish. The pike-perch is a very active hunter, and it is not at all probable that one can live and thrive on less than three such meals a week. The specimens above mentioned were taken in cold autumn weather, when most other fishes were eating but little; but since fishes generally take relatively little food in winter, we will suppose that the pike-perch eats, during the year, on an average, at this rate per week for forty weeks, giving us a total *per annum* of six hundred gizzard shad destroyed by one pike-perch. We cannot reckon the average life of a pike-perch at less than three years, and it is probably nearer five. The smallest estimate we can reasonably make of the food of each pike-perch would therefore be somewhere between eighteen hundred and three thousand fishes like the gizzard shad. A hundred pike-perch, such as should be taken each year along a few miles of a river like the Illinois, would therefore require from one hundred and eighty thousand to three hundred thousand fishes for their food. Finally, when we take into account the fact that a number of other species also prey upon the gizzard shad, and that the whole number destroyed in all ways must not exceed the mere surplus reproduced—otherwise the species would soon be extinguished—we can form an approximate idea of the multitudes in which the food species must abound if we would support any great number of predaceous fishes. The gizzard shad, being a mud-eater and a vegetarian, taking little animal food except when very young, can probably be more readily maintained in large numbers in our muddy streams than any other fish.

The two species of black bass differ, according to my observations, in the character of their food, the large-mouthed species eating more fishes and the small-mouthed more crayfishes. Here, also, the gizzard shad made more than half the food.

The common sunfishes are readily divisible into four groups, based on their feeding structures and their food; one characterized especially by the wide mouth, including the black warrior and the blue-checked sunfish, took a noticeable amount of fishes, the ratio varying from a third to a half, the remainder of the food being chiefly insects, crayfishes and smaller crustaceans. Those with small mouths, pointed teeth in the throat, and short gill-rakers, like the most abundant of the river species, took scarcely any fishes, but fed chiefly on insects and crustaceans, the latter principally the forms of medium size (amphipods and isopods). Some of this group likewise took a large amount of vegetation, amounting to a third or fourth of the whole.

A group with small mouths and blunt conical teeth in the throat, illustrated by the common bream or pumpkin seed, was distinguished especially by the number of small snail-like mollusks eaten, these making, in my specimens, more than a third of the food. The remainder was chiefly aquatic insect larvæ, the medium-sized crustacea and water plants.

The fourth group, illustrated by the croppies, have the mouth long but narrow, and the gill-rakers numerous and long. By these a few fishes are taken, but the food is chiefly insects and the smallest crustaceans—those commonly referred to as entomostraca, a food resource which they are enabled to draw upon by the straining apparatus in the gills.

Passing to the pike or pickerel of our Western rivers, I find that the common large river pike, *Esox lucius*, is almost wholly piscivorous, a single specimen only out of the thirty-seven examined, having taken a number of dragon flies. About a fifth of the fishes were sunfishes (half of them croppies) and black bass. Twenty of these thirty-seven pike had taken gizzard shad, which made, in fact, nearly half of the food of the entire group. Minnows were found in only two, and three had eaten buffalo fish.

The striking features of this record are the importance of the gizzard shad, the abundance of the spiny-finned fishes, including some of the most valuable kinds, and the insignificant number of minnows and suckers taken.

The grass pickerel, a species which rarely reaches a foot in length, had eaten tadpoles of frogs, and fishes and insects, the latter making more than a third of the food, and consisting chiefly of the larvæ of dragon flies.

The gizzard shad, mentioned above as an especially valuable element of the food of the higher fishes, feeds itself almost wholly upon mud, with which the long and coiled intestine of every specimen was filled from end to end. This mud contained, on an average, about twenty per cent. of minute vegetable *debris*, with occasionally a little animal matter.

The great minnow family I can scarcely pass by, since it contributes so largely to the food of other fishes, although itself of little or no direct advantage to mankind. I found this family dividing into several groups based upon the length of the intestine and the form of the pharyngeal teeth. In the first of these groups, containing several of the more abundant sorts,

about three-fourths of the food consisted of soft black mud, the remainder being both animal and vegetable matter, chiefly the latter. These fishes all had very long intestines and smooth grinding teeth in the throat. In another group quantities of mud are also taken, but with it many *Entomostraca*, while in groups three and four, containing by far the greater portion of the family, the food is essentially different, about three-fourths of it being insects and small crustaceans, and the remainder vegetation. I note especially here the value of the mud-eating minnows as food for larger fishes, since while abundant and easily maintained, they do not compete with the young of the larger fishes to whose sustenance they may be applied.

One of the most striking characteristics of the fish-fauna of the Mississippi valley is the prominence of the sucker family, several of which are among the most abundant of our larger fishes. About one-tenth the food of this family, taken as a whole, consisted of vegetation, eaten chiefly by the buffalo fishes, and in them composed largely of distillery slops. The family is, however, essentially carnivorous, mollusks and insects appearing in nearly equal ratio in the food. The former are taken much the more generally by the cylindrical suckers, and the latter about equally by all except the stone roller, which collects great quantities of insect food by pushing about the stones in running water. A large proportion of the insects eaten are small larvæ of gnats (*Chironomus*). Some of the deeper-bodied species with long gill-rakers, especially the river carp, feed largely on *Entomostraca*, this latter species swallowing also considerable quantities of mud.

The catfishes, taken together, are nearly omnivorous in habit, and their feeding structures have a correspondingly general character. The capacious mouth, wide gullet, and short, broad stomach admit objects of large size and nearly every shape. The jaws, each armed with a broad pad of fine, sharp teeth, are well calculated to grasp and hold soft bodies as well as hard. The gill-rakers are of average number and development, and crushing jaws in the throat, broad, stout arches below, and oval pads above, covered with minute pointed teeth, serve fairly well to break the crusts of insects and the shells of the smaller mollusks, and to squeeze and grind the vegetable objects which occur in the food. The most peculiar feeding habit relates to the larger bivalve mollusks, the bodies of which are frequently found almost entire in the stomachs of these fishes and always without a fragment of a shell. I have been repeatedly assured by fishermen that the catfish seizes the foot of the mollusk while the latter is extended from the shell, and tears the animal loose by vigorously jerking and rubbing it about. One intelligent fisherman informed me that he was often first notified of the presence of catfishes in his seine, in making a haul, by seeing the fragments of clams floating on the surface, disgorged by the struggling captives. Finally, these are the only habitual scavengers among our common fishes. The larger deep-water species from the great rivers are strictly piscivorous, so far as known. Very small stone-cats feed on the smaller insect larvæ and the medium-sized crustacea. The spotted cat, blue Fulton, or fiddler, feeds largely on mollusks, but is, nevertheless, chiefly insectivorous. It differs from most of the river catfishes by eating water-plants to a considerable extent. The common bullhead is more strictly omnivorous than any other kind, its food being composed about equally of fishes, mollusks, aquatic insects, and vegetable structures, with a very considerable ratio of crustaceans added. The great mud-cat, or Morgan cat, reaching a weight of over one hundred pounds, seems to feed entirely upon fishes.

The abundant and peculiar dogfish, or "grindle," is strictly carnivorous, about one-third of the food being fishes, a fourth of it small mollusks, and nearly half crustaceans, chiefly crayfish.

The gars are all strictly piscivorous, feeding especially upon the gizzard shad.

The most remarkable of our fishes, in structure and feeding habit, is the shovel-fish, or "spoonbill," of the Mississippi and its larger tributaries. It is a large species, reaching a weight of thirty pounds and upwards and a length of six feet or more, including the paddle-like snout. Although so large, the greater part of its food consists of the smallest aquatic Crustacea and insect larvæ, strained from the water by means of an extraordinary apparatus in the gills, composed of long and slender gill-rakers, a double series on each arch, and over five hundred in a series. Interlocking as these do when the gill apparatus is extended, they form a strainer sufficient to arrest the smallest living forms above the Protozoa, and with the immense opening of the mouth and equally free provision for the exit of water from the gill chamber, enable this fish to strain out enormous quantities of these minute animal forms, especially those most commonly reserved for young fishes. It takes also, in midsummer, insect larvæ of medium size, but evidently avoids vegetation, and never swallows mud.

FOOD OF THE YOUNG.

By an examination of three hundred and one specimens, representing twenty-seven species, twenty-six genera and twelve families of Illinois fishes, I learn that the food of many species of fishes differs greatly according to age; and that, in fact, the life of most of our fishes divides into at least two periods, and that of many into three, with respect to the kinds of food chiefly taken. Further, in the first of these periods a remarkable similarity of food was noticed among species whose later feeding habits are widely different. The full-grown black bass, for example, feeds principally of fishes and crayfishes, the sheepshead on mollusks, and the gizzard shad on mud and Algæ, while the catfishes are nearly omnivorous; yet all these agree so closely in food when very small, that one could not possibly tell from the contents of the stomachs which group he was dealing with.

In the earliest stage, all the fishes studied, except suckers and minnows, depend for food on the smallest crustaceans, commonly called Entomostraca, and on certain small worm-like larvæ of gnats or gnat-like flies scarcely larger than these crustaceans, and usually occurring with them. By far the most abundant of these insect larvæ was that known as Chironomus. The suckers and minnows differ from our other fishes by being toothless while very young, as well as when adult, while our other toothless fishes, gizzard shad, whitefish, etc., have in youth a set of evanescent teeth. These toothless young I found feeding in part on still smaller prey than the others, taking the smallest animal forms (wheel animalcules), various Protozoa, and Algæ so minute that the whole plant consists of a single vegetable cell. The food of the whitefish fry was determined by keeping several hundred of them in a large aquarium kept constantly supplied with all the living objects which a fine gauze net would separate from the waters of Lake Michigan.*

While small fishes of all sorts are evidently competitors for food, this com-

*See note following this paper.

petition is relieved to some extent by differences of breeding season, t[h]e species dropping in successively to the banquet, some commencing in ve[ry] early spring, or even, like the whitefish, depositing their eggs in fall, th[at] their young may be the first at the board, while others delay until June o[r] July. The most active breeding period coincides, however, with that of th[e] greatest evolution of *Entomostraca* in the back-waters of our streams; th[at] is, the early spring. That large adult fishes with fine and numerous raker[s] on the gills—like the shovel fish and the river carp—many compete directl[y] with the young of all other species, and tend to keep their numbers down b[y] diminishing their food supply—especially in times of scarcity—is very probabl[e] but is not certainly true as a general thing; for these larger fishes have othe[r] food resources, also, and many resort to Entomostraca only when these ar[e] superabundant, thus appropriating the mere excess above what are require[d] for the young of other groups. Of the fishes which emerge from this earlies[t] stage through increase in size with failure to develop alimentary structure[s] especially fitted to the appropriation of minute animal forms, some becom[e] mud-eaters, like the *Campostoma* and the gizzard shad; a few apparentl[y] become vegetarians at once; but most pass into or through an insectivorou[s] stage. After this a few become nearly omnivorous, like the bullhead; other[s] learn to depend chiefly on molluscan food—the sheepshead and the red horse species; but many become essentially carnivorous. In fact, unless the gars are an exception, as they now seem to be (attacking young fishes almost as soon as they can swallow), all our specially carnivorous fishes make a progress of three steps, marked, respectively, by the predominance of Entomostraca, insects, and fishes in their food; and the same is true of those strictly fitted for a molluscan diet.

PRINCIPAL ELEMENTS OF THE FOOD.

An analysis of the facts made with reference to the kinds of fishes eating each of the principal articles in the dietary of the class, and showing the relative importance of these elements in the food of the various species, will have its separate interest for us, especially as it will exhibit the competition of fishes for food, and also the nature and the energy of the restraints imposed by fishes on the multiplication of their principal food species.

The principal fish-eaters among our fishes—those whose average food in the adult stage consists of seventy-five per cent., or more, of fishes—are the burbot, the pike-perch or wall-eyed pike, the common pike or pickerel, the large-mouthed black bass, the channel-cat, the mud-cat and the gars. Possibly, also, the golden shad will be found strictly ichthyophagous, this being the case with the four specimens which I studied. Those which take fishes in considerable but moderate amount—the ratios ranging in my specimens from twenty-five to sixty-five per cent.—are the war-mouth (*Chænobryttus*), the blue-cheeked sunfish, the grass pickerel, the dog-fish, the spotted cat and the small miller's thumb. The white and the striped bass, the common perch, the remaining sunfishes (those with smaller mouths), the rock bass and the croppie take but few fishes, these making, according to my observations, not less than five nor more than twenty-five per cent. of their food. Those which never capture living fishes, or, at most, to a merely trivial extent, are the white perch or sheepshead, the gizzard shad, the suckers and the shovel fish among the larger species; and the darters, the brook silversides, the stickleback, the mud minnows, the top minnows, the stone-cats and the common minnows generally among the smaller kinds. Our eight specimens of the toothed herring had taken no fishes whatever; while our nineteen examples of the pirate perch had eaten only two per cent.

Rough-scaled fishes with spiny fins were eaten by the miller's thumb, the common pike, the wall-eyed pike, the large-mouthed black bass, the croppies, the dog-fish, the common perch, the burbot, the bullhead, the common sunfish (*Lepomis pallidus*), the small-mouthed black bass, the grass pickerel, the gar and the mud-cat (*Leptops*). Among these, the common perch and the sunfishes were most frequently taken—doubtless owing to their greater relative abundance—the perch occurring in the food of the burbot, the large-mouthed black bass and the bullhead; and the sunfishes in both species of wall-eyed pike, the common pike, the gars, pickerel, bullheads and mud-cat. Black bass were taken from the common pike (*Esox*), the wall-eyed pike (*Stizostedion*) and the gar. Croppie and rock bass I recognized only in the pike. Even the catfishes with their stout, sharp and poisoned spines were more frequently eaten than would have been expected—taken, according to my notes, by the wall-eyed pike, both black bass, and a fellow species of the family, the *goujon* or mud-cat.

The soft-finned fishes were not very much more abundant, on the whole, in the stomachs of other species, than those with ctenoid scales, spiny fins and other defensive structures, an unexpected circumstance which I cannot at present explain, because I do not know whether it expresses a normal and fixed relation, or whether it may not be due to human interference.

Only the catfishes seem to have acquired defensive structures equal to their protection, the predatory apparatus of the carnivorous fishes having otherwise outrun in development the protective armor of the best-defended species.

Among the soft-finned species the most valuable as food for other fish is the gizzard shad, *Dorosoma*, this single fish being about twice as common in adults as all the minnow family taken together. It made forty per cent. of the food of the wall-eyed pike; a third that of the black bass; nearly half that of the common pike or "pickerel;" two-thirds that of the four specimens of golden shad examined; and a third of the food of the gars. The only other fishes in whose stomachs it was recognized were the yellow cat, *Ictalurus natalis*, and young white bass, Roccus. It thus seems to be the especial food of the large game fishes and other particularly predaceous kinds.

The minnow family (Cyprinidæ) are in our waters especially appropriated to the support of the half-grown game fishes, and the smaller carnivorous kinds. They were found in the wall-eyed pike, the perch, the black bass, the blue-cheeked sunfish, the croppie, the pirate perch, the pike, the little pickerel, the chub minnow, the yellow cat, the mud-cat, the dogfish, and the gar.

Suckers, Catostomatidæ, I determined only from the pike, the sheepshead, the blue-cheeked sunfish (*cyanellus*), the yellow cat, and the dogfish (*Amia*). Buffalo and carp occurred in the pike, the dogfish, and the above sunfish.

The ponds and muddy streams of the Mississippi valley are the native home of mollusks of remarkable variety and number, and these form a feature of the fauna of the region not less conspicuous and important than its leading groups of fishes. We might, therefore, reasonably expect to find these dominant groups connected by the food relation; and consistently with this

expectation, we observe that the sheepshead, the catfishes, the suckers a the dogfish find an important part of their food in the molluscan for abundant in the waters which they themselves most frequent. The class a whole makes about one-fourth of the food of the dogfish and the sheepsh —taking the latter as they come, half-grown and adults together—about h that of the cylindrical suckers—rising to sixty per cent in the red horse—a a considerable ratio (fourteen to sixteen per cent) of the food of the per the common catfishes (Amiurus and Ictalurus), the small-mouthed sunfish the top minnows, and the shiner (Notemigonus). Notwithstanding t abundance of the fresh-water clams or river mussels (Unio and Anodonta only a single river fish is especially adapted to their destruction, viz., t white perch or sheepshead, and this species derives, on the whole, a larg part of its food from univalve than from bivalve mollusks, the former eat especially by half-grown specimens, and the latter being the chief dependen of the adults. The ability of the catfishes to tear the less powerful cla from their shells has been already mentioned. Large clams were eaten free by the full-grown sheepshead—whose enormous and powerful pharyng jaws with their solid pavement teeth are especially adapted to crushing t shells of mollusks—and by the bullheads (Amiurus), especially the marbl cat. The small and thin-shelled Sphæriums are much more frequent objects in the food of the mollusk-eating fishes than are the Unios. Th genus alone made twenty-nine per cent of the food of our one hundred an seven specimens of the sucker family, and nineteen per cent of that of a doz dogfishes. Among the suckers it was eaten greedily by both the cylindric and the deep-bodied species, although somewhat more freely by the forme Even the river carp, with its weak pharyngeal jaws and delicate teeth, fin these sufficient to crush the shells of Sphærium, and our nineteen specime had obtained about one-fourth of their food from this genus. Besides th above families, smaller quantities of the bivalve mollusks occurred in the foo of one of the sunfishes (*Lepomis pallidus*), and—doubtless by accident only— in the gizzard shad. The gasteropod mollusks (snails of various description were more abundant than bivalve forms in the sheepshead, sunfish, and all th smaller fishes which feed upon Mollusca, but less abundant in the suckers an the catfishes. In the sheepshead they made one-fifth of the food of th twenty-five specimens examined, but the greater part of these had not y passed the insectivorous stage, this being much longer continued in th sheepshead than in many other fishes. A few of these univalve Mollusc occurred in the food of the common perch and in certain species of sunfishe —especially the superabundant bream or pumpkin-seed. They made fifte per cent of the food of the minute top minnows, and occurred in smalle quantities among the darters, the little pickerel, the mud minnows, and th cyprinoids. The heavier river snails, Vivipara and Melantho, were eate especially by the cylindrical suckers and the catfishes. The delicate pon snails (Succinea, Lemna, and Physa) were taken chiefly by the smaller mol lusk-eating fishes— a few of them also by the catfishes and the suckers.

It is from the class of insects that adult fishes derive the most important portion of their food; and, taken as a whole, this class furnishes thirty-eight per cent of the food of all which I examined. The principal insectivorous fishes are the smaller species, whose size and food structures, when adult, unfit them for the capture of Entomostraca and yet do not bring them within reach of fishes or Mollusca. Some of these fishes have peculiar habits which render them especially dependent upon insect life—the little minnow, Phenacobius, for example, which, according to my studies, makes nearly all its food (ninety-eight per cent.) from insects found under stones in running water. Next are the pirate perch, Aphredoderus (ninety-one per cent.); then the darters (eighty-seven per cent.), the croppies (seventy-three per cent.), half-grown sheepshead (seventy-one per cent.), the shovel fish (fifty-nine per cent.), the chub minnow, Semotilus (fifty-six per cent.), the black warrior sunfish (Chænobryttus) and the brook silversides (each fifty-four per cent.), and the rock bass and the cyprinoid genus Notropis (each fifty-two per cent).

Those which take few insects or none are mostly the mud feeders and the ichthyophagous species, Amia, (the dog-fish) being the only exception to this general statement. Thus we find insects wholly or nearly absent from the adult dietary of the burbot, the pike, the gar, the black bass, the wall-eyed pike, and the great river catfish, and from that of the hickory shad and the mud-eating minnows (the shiner, the fat-head, etc.). It is to be remembered, however, that the larger fishes all go through an insectivorous stage, whether their food when adult be almost wholly other fishes, as with the gar and the pike, or mollusks, as with the sheepshead. The mud-feeders, however, seem not to pass through this stage, but to adopt the limophagous habit as soon as they cease to depend upon Entomostraca.

Terrestrial insects, dropping into the water accidentally or swept in by rains, are evidently diligently sought and largely depended upon by several species, such as the pirate perch, the brook minnow, the top minnows or killifishes (Cyprinodonticlæ), the toothed herring and several cyprinoids (Semotilus, Pimephales, and Notropis).

Among aquatic insects, minute, slender dipterous larvæ are of remarkable importance, making, in fact, nearly one-twelfth of the food of all the fishes studied. They amounted to about one-third the food in fishes as large and important as the red horse and the river carp, and made nearly one-fourth that of fifty-one buffalo fishes. They appear further in considerable quantity in the food of a number of the minnow family (Notropis, Pimephales, etc.), which habitually frequent the swift water of stony streams. Aquatic beetles and larvæ, notwithstanding the abundance of some of the forms, occurred in only insignificant ratios, but were taken by fifty-six specimens. The adult surface beetles, whose zig-zag darting swarms no one can have failed to notice, were not once encountered in my studies.

The almost equally well-known slender water-skippers seem also completely protected by their habits and activity from capture by fishes, only one occurring in the food of all our specimens.

It is from the order Neuroptera that fishes draw a larger part of their food than from any other single insect group. In fact, nearly one-sixth of the entire amount of food consumed by all the fishes examined by me consisted of aquatic larvæ of this order, the greater part of them larvæ of day flies. These Neuroptera larvæ were eaten especially by the miller's thumbs, the sheepshead, the white and striped bass, the common perch, thirteen species of the darters, both the black bass, seven of the sunfishes, the rock bass and the croppies, the pirate perch, the brook silversides, the sticklebacks, the mud minnow, three top minnows, the gizzard shad, the toothed herring, twelve species each of the true minnow family and of the suckers and buffalo, five catfishes, the dogfish and the shovel-fish—seventy species out of the eighty-seven which I studied.

Of the four principal classes of the food of fishes, viz., fishes, mollusk insects, and *Crustacea*, the latter stand third in importance according to m observations, mollusks alone being inferior to them. That insect larvæ shou be more abundant in the food of fresh water fishes than are crustaceans, is somewhat unexpected fact, but while the former make about twenty-five p cent. of the food of our entire collection, the crustaceans amount to on fourteen per cent. Crayfishes made about a sixth of the food of the burbo about a tenth that of the common perch, a fourth that of half a dozen gar and not far from a third that of the black bass, * the dogfish, and our fo rock bass. Young crayfishes appeared quite frequently in some of the larg minnows (Semotilus and Hybopsis), and also in catfishes, especially th pond and river bullheads, averaging nearly fifteen per cent. of the entir food of the two most abundant species.

The minute crustaceans commonly grouped as Entomostraca are a muc more important element. Among full-grown fishes, I find them especiall important in the shovel-fish—where they made two-thirds of the food of th specimens studied—and in the common lake herring. Among the sunfishe at large they were present in only insignificant ratio; but the croppies, dis tinguished by long and numerous rakers on the anterior gill, had derive about a tenth of their food from these minute crustaceans. In the earl spring, especially, when the backwaters of the streams are filled with Entomostraca, the stomachs of these fishes are often distended with the commonest forms. Ten per cent. of the food of the sucker family consisted of them, mostly taken by the deep-bodied species, in which they made a fourth or a fifth of the entire food. This fact is explained, it will be remembered, by the relatively long, slender, and numerous gill-rakers of these fishes. Large river buffalo were occasionally crammed with the smallest of these Entomostraca, only a twenty-fifth of an inch in length.

I have several times remarked the peculiar importance of Entomostraca to the shovel-fish—one of the largest of our fresh-water animals—a fact accounted for by the remarkable branchial strainer of this species, probably the most efficient apparatus of its kind known to the ichthyologist. Here, again, the smallest forms were the most abundant.

Probably to those accustomed to the abundance of true worms in marine situations, no feature of the poverty of fresh-water life will be more striking than the small number of this subkingdom occurring in the course of miscellaneous aquatic collections in the interior. Similarly, we notice that in the food of fishes the occurrence of Vermes is so rarely noticed that they might be left out of account entirely without appreciably affecting any of the important ratios. Catfishes alone seem purposely to eat leeches, these occurring in nine specimens of three different species of this family, and also in one common sucker and in a single shovel-fish. One of the fresh-water *Sponges* (Spongilla) had been eaten in considerable quantities by two examples of the spotted cat taken in September, but this element was not encountered elsewhere in my studies.

That the minutest and simplest of all the animal forms, far too small for the eye of a fish to see without a microscope, should have been recognized in the food of seventeen species of fishes is, of course, to be explained only as an incident of the feeding habit. It is possible, however, that these *Proto-*

* Our specimens—especially of the small-mouthed black bass—were too few in number to make this average reliable.

zoa, where especially abundant, may be recognized in the mass by the delicate sensory structures of the fish; and they seem in most cases to have been taken with mud and slime, rich in organic substances. As most of them are extremely perishable, and can scarcely leave a trace a few seconds after immersion in the gastric juices of the fish, it is probable that they contribute much more generally than our observations indicate to the food of some fishes, especially to those which feed upon the bottom.

Young suckers under six inches in length clearly take them purposely, substituting them in great part for the Entomostraca taken by other fishes of their size and age.

I detected Protozoa in the food of several genera of Cyprinidæ, in the young of buffalo, the river carp, the chub sucker, the red-horse, the stone roller, in the common sucker, in a single gizzard shad, in a stone-cat, and in a top minnow.

The only scavenger fishes of our collection were three species of the common catfishes; the spotted cat, the yellow cat, and the marbled cat—all of which had eaten dead animal matter, including pieces of fish, ham, mice, kittens, and the like. A single large-mouthed black bass had likewise eaten food of this description.

Considering the wealth of vegetation accessible to aquactic animals, and the fact that few other strictly aquatic kinds have the vegetarian habit, it is indeed remarkable that fishes draw from plants an unimportant part of their diet. Taking our nine hundred specimens together, the vegetation eaten by them certainly would have amounted to less than ten per cent of their entire food, and excluding vegetable objects apparently taken by chance, it probably would not reach five per cent.

The greatest vegetarians are among the minnow family. Counting each genus as a unit, I find that the family as a whole obtained from plants about twenty-three per cent of its food. The little Phenicobius, already reported as strictly insectivorous, was the only one studied in which vegetation can scarcely be said to occur.

Certain of the sunfishes evidently take plant food purposely on occasion, this making, for example, nearly a tenth of the food of forty-seven specimens of Lepomis. Among the larger fishes, the principal vegetarians are the gizzard shad, in which this element was reckoned at about a third, taken, however, not separately, but with quantities of mud. A considerable part of the vegetation here included consisted of distillery slops obtained near towns. The buffalo fishes are likewise largely vegetarians, more than a fourth of their food coming from the vegetable kingdom; about a third of this in our specimens being refuse from distilleries. Vegetation made a tenth of the food of the larger genera of catfishes (Amiurus and Ictalurus)—some of it distillery refuse—and nearly as large a ratio of the great Polyodon.

Not infrequently terrestrial vegetable rubbish—seeds of grasses, leaves of plants, and similar matter—was taken in quantity to make it certain that its appropriation was not accidental. The principal mud-eating fishes are the gizzard shad, the common shiner, and certain genera of minnows with elongate intestines and cultrate pharyngeal teeth. Much mud was also taken by the cylindrical members of the sucker family, but apparently as an incident to their search for mollusks.

CONCLUSION.

I cannot attempt to discuss the practical bearing of the mass of data he[re] presented, or of the much greater number which I have withheld, partl[y] because the time is lacking, and partly because I know too little of practic[al] fish-culture; and I will merely call attention to a few illustrative poin[ts] which have occurred to me in writing.

It would seem that the fact that all young fishes compete, at first, fo[r] food must have important practical results tending in various directions. I[t] is probable that all fishes which are not especially adapted to the food require[-] ments of the more valuable fishes are hurtful to them, because they limit th[e] food available for their young. It seems possible that even the food species o[f] the predaceous fishes may multiply to an extent injurious to the latter, sinc[e] both robber and prey compete while young for the same elements of food. I[t] would seem entirely likely that large fishes, like the shovel-fish, which destro[y] when adult immense quantities of the proper food of the young, must b[e] reckoned as injurious.

Again, it is evident that the fishes most desirable as food for other kind[s] are those whose own food is not eaten by valuable species, but exists in practically inexhaustible supplies. The gizzard shad and the mud-feeding minnows are examples of this sort; while the red-horse and other cylindrical suckers answer the purpose almost equally well, since no valuable fishes feed upon mollusks (especially preferred by suckers), and these are among the most abundant animals in our western streams. The fact that they have likewise adapted themselves to civilization, so far at least as to relish distillery slops, is, perhaps, an additional recommendation from this point of view.

The smaller catfishes, being practically omnivorous, are the rivals of every other kind; and being almost perfectly protected from capture by their stout, sharp, poisoned spines, they contribute little to the food supply of other fishes. The common sunfishes are almost equally worthless and injurious from this point of view.

I need scarcely say that the fish-culturist should examine the waters in which young fishes are planted, in order to determine the amount of their appropriate food available. It is not impossible that myriads of whitefish have been set free to perish by starvation before the feeble fry could disperse widely enough to secure a single meal. It seems to me, also, that in every case where it is proposed to introduce a new fish into waters already populated, the first question to be asked should be, what fishes do these waters already contain—and in what numbers—whose food and whose relations to nature generally are substantially the same as those it is intended to introduce?

And, finally, I would call attention to the necessity of keeping continuous watch of the balance and abundance of plant and animal life in its various leading forms in any body of water in which it is thought desirable to maintain especial kinds of fishes in the greatest number possible. The owner of a fish-pond especially, who makes himself acquainted with the entire collection of animals and plants which his pond contains, and keeps the run of these in their variations of number and habit, from season to season and from year to year, will not only get some practical hints thereby, which will aid him in the multiplication and preservation of his fish, but will derive no small amount of pleasure from his observations, and from the reasonings and reflections to which they will give rise.

NOTE ON THE FIRST FOOD OF THE WHITEFISH.

An elaborate account of this research was published in 1883, in the first volume of the Bulletin of the Illinois State Laboratory of Natural History; but as this article was not widely distributed among fish-culturists, the great practical importance of the subject will perhaps justify the following extracts from it: More light was thrown upon the earliest food habits of these fishes by the discovery of raptatorial teeth upon the lower jaw than by the dissections of their alimentary canals. All the families of fishes which I had previously studied whose young were provided with teeth were found strictly dependent at first upon *Entomostraca* and the minuter insect larvæ; while only those whose young were toothless fed to any considerable extent upon other forms. The discovery of teeth in the young whitefish, therefore, placed this species definitely in the group of those carnivorous when young. The fact that the adult was itself toothless interfered in no way with this inference, because other toothless fishes (*Dorosoma*) whose young were furnished with teeth had been found carnivorous at an early age.

The inconclusive character of the results thus far obtained made it necessary to attempt to imitate more closely the natural conditions of the young when hatched in the lake. In February, 1881, I obtained, through the kindness of Mr. Clarke, twenty-five specimens of living young whitefish, saved from a lot which he was planting in the waters of Lake Michigan, off Racine, Wisconsin. I succeeded in conveying them to the laboratory without loss, and there kept them for several days in a glass aquarium and supplied them with an abundance of the living objects to be obtained by drawing a fine muslin net through the stagnant pools of the vicinity. These consisted of many diatoms and filamentous fresh-water Algæ, of two or three species of Cyclops, of *Canthocamptus illinoisensis*, and *Diaptomus sanguineus* among the Copepoda, and of two rather large Cladocera, *Simocephalus vetulus* and *S. americanus*. These little fishes were kept under careful observation for several days, the water in the aquarium being frequently aërated by pouring. Many of them had, however, been injured by handling, and eleven of the specimens died without taking food. It was soon evident that the larger Entomostraca (the *Simocephalus*, and even the *Diaptomus*) were quite beyond the size and strength of these little fishes, and that only the smaller Copepoda, among the animals available, could afford them any food at first. These they followed about from the beginning with signs of peculiar interest, occasionally making irresolute attempts to capture them. Two days after their arrival one of the young whitefish had evidently taken food, which proved, on dissection, to be a small Cyclops. During the next two days nine others began to eat, dividing their attention between the Cyclops above mentioned and the Canthocamptus, and on the 22d two others took a Cyclops each and

a third a Canthocamptus. One of these fishes contained still a large remnant of the egg-sac, showing that the propensity to capture prey must antedate the sensation of hunger. On the 25th the fourteenth and last remaining fish captured its Cyclops, and was itself sacrificed in turn. As an indication of the efficiency of the raptatorial teeth, it may be worth while to note that I saw one of the smallest fishes make a spring at a Cyclops, catch it, give three or four violent wriggles, and drop it dead to the bottom of the tank.

As a general statement of the result of the observations made on these fourteen fishes, we may say that eight of them ate a single Cyclops each, that one took two and another three of the same, that one took a single Canthocamptus, that two specimens captured two each of this genus, and that finally a single fish ate Cyclops and Canthocamptus both. The final conclusion was a highly probable inference that the smallest Entomostraca occurring in the lake would prove to be the natural food of the species.

In order to test this conclusion with precision, I arranged a similar experiment on a larger scale, and under more natural conditions. Through the generosity of the Exposition Company, of Chicago, I was allowed the use of one of the large aquarium tanks in the Exposition building, on the lake shore, and by the repeated kindness of Mr. Clarke, of Northville, Michigan, I was furnished with a much larger number of living whitefish. Five thousand fry were shipped to me in a can of water, but through unfortunate delays in changing cars at intermediate points, about two-thirds of these were dead when they reached my hands. Those living were immediately transferred to the tank, through which the water, taken from the city pipes, had already been allowed to run for several hours. As this water is derived from Lake Michigan at a distance of two miles from the shore, and had to this time the exact temperature of the open lake, the conditions for experiment were as favorable as artificial arrangements could well be made.

Sending a man with a towing net out upon the lake with a boat, or upon the remotest breakwaters, immense numbers of all organic objects in the waters were easily obtained. After enclosing the exit of the tank with a fine wire screen, to prevent the escape of objects placed in it, we poured these collections of all descriptions indiscriminately into the water from day to day, thus keeping the fishes profusely supplied with all the various kinds of food which could possibly be accessible to them in their native haunts. From this tank one hundred fishes were taken daily and placed in alcohol for dissection and microscopic study, to determine precisely the objects preferred by them for food. These were examined at a later date, and all contents of the intestines were mounted entire as microscopic slides, and permanently preserved. A careful study was, of course, made of the organisms of the lake, as shown by the product of the towing-net, and when the experiment was finally ended, it was followed by an equally careful examination of the living contents of the water of the tank at that time.

These fishes, like those previously described, had already reached the age and condition at which it is customary to "plant" them in the lake. The ventrals were still undeveloped, the egg sac had nearly disappeared, the four mandibular teeth were present, and the median fin extended from the tips of the pectorals on the belly to a point opposite the middle of the same fins on the back. In most the egg-sac did not protrude externally, being reduced in some to a droplet of oil, but remaining in a few of a size at least as great as that of the head. The alimentary canal was, of course, a simple, straight tube, without any distinction of stomach and intestines.

The sufferings of these fry in transit had doubtless weakened the vitality of these survivors, and although every care was taken to keep the water of the tank fresh and pure, about one-third of those remaining died during the progress of the experiment. The aquarium in which they were confined was built of glass, and had a capacity of about one hundred cubic feet. The temperature, tried repeatedly, stood at forty-two Fahrenheit. A steady current of the water of the lake was maintained through this tank, entering through a rose, from which it fell in a spray, thus insuring perfect aëration.

By far the greater part of the organic contents of the water of the lake, as shown by the product of the towing-net, consisted of diatoms in immense variety, which formed always a greenish mucilaginous coating upon the interior of the muslin net. In this were entangled a variety of rotifers, occasional filamentous Algæ, and many Entomostraca, the latter belonging chiefly to the genera Cyclops, Diaptomus and Limnocalanus among the Copepoda, and to Daphnia among the Cladocera.

As the Entomostraca proved to be far the most important elements of this food supply, the particulars respecting them may be properly more fully given. The smallest of all was a Cyclops, then new, but since described by me under the name of *Cyclops thomasi*.* This little Entomostracan is only .04 inch long by .011 wide. The next in size, and by far the most abundant member of this group, was a Diaptomus, likewise new, described in the paper just cited under the name of *Diaptomus sicilis*. This appears in two forms, one, evidently young, in the stage just preceding the adult. Full-grown individuals were .065 inch long by one-fourth that depth. The Limnocalanus was a much larger form, evidently preying, to a considerable extent, upon the two just mentioned. All the Cladocera noticed were *Daphnia hyalina*, an elegant and extremely transparent species, occurring likewise in the lakes of Europe. A single insect larval form (Chironomus) should likewise be mentioned in this connection, since it had about the same size and consistence of the Entomostraca, and was consequently available for food. The specimens of each of the above species from a certain quantity of these collections were counted, in order to give a definite idea of their relative abundance in the lake; the Diaptomus numbered 225, the Cyclops 75, Limnocalanus 7, Daphnia 3, and Chironomus larvæ 1. It was a curious fact, however, that when the water was drawn off at the end of the experiment, more than half the Entomostraca were Limnocalanus; a fact partly to be explained by the predaceous habit of the latter and partly by the facts relating to the food of the fishes themselves, which are presently to be detailed. The fry were placed in the tank and supplied with their first food on the evening of the 12th of March. On the 14th one hundred specimens were removed, and twenty-seven of these were dissected. Twenty were empty, but the remaining seven had already taken food, all Cyclops or Diaptomus. Three had eaten Cyclops only, and six Diaptomus, while two had eaten both. Fourteen of these Entomostraca, seven of each genus, were taken by these seven fishes. From those captured the next day, twenty-five specimens were examined, of which nineteen were without food. Of the remaining six, three had eaten Diaptomus and three Cyclops; five of the former being taken in all, and ten of the latter. Three specimens were next examined from those caught on the 19th of March, two of which had devoured Diaptomus, and a third a single *Cyclops thomasi* and a shelled rotifer, *Anuræa striata*. The character of the food at these earliest stages was so well settled by these observations that I deemed it unnecessary to examine the subsequent lots in detail, but passed at once to the specimens taken on the 23d. Twenty-six of these were examined and found to have eaten thirty-three individuals of *Cyclops thomasi*, fourteen of *Diaptomus sicilis*, and fourteen of the minute rotifer already mentioned (*Anuræa striata*). Two had taken a few diatoms (Bacillaria), and one had eaten a filament of an Alga. Cyclops was found in sixteen of the specimens, Diaptomus in nine, and Anuræa in eight, only two of them being empty. The amount of food now taken by individual fishes was much greater than before, one specimen dissected having eaten two Cyclops and six *Diaptomus sicilis*, male and female. Another had taken five Cyclops, one Diaptomus and five examples of *Anuræa striata*. Still another had eaten four of the Cyclops, four Diaptomus and one Anuræa.

*"On some Entromostraca of Lake Michigan and Adjacent Waters." American Naturalist Vol. XVI., No. VIII. (August, 1882), pp. 640 and 649.

Twenty-five specimens were examined from those removed on the 24th of the month, at which time the water of the tank was drawn off and all the remaining fishes bottled. Four of these had not eaten, but the twenty-one others had devoured fifty specimens of *Diaptomus sicilis*, forty-seven of *Cyclops thomasi*, fourteen of *Anuræa striata* and a single *Daphnia hyalina*, the latter being the largest object eaten by any of the fishes. A few examples of their capacity may well be given. The ninth example had eaten six Diaptomus, two *Cyclops thomasi* and one Anuræa; the tenth had taken eight Diaptomus, two Cyclops and an Anuræa; and the twentieth seven Diaptomus and three *Cyclops thomasi*. In two of these examples were small clusters of orange globules, probably representing unicellular Algæ.

Summarizing these data briefly, we find that of the one hundred and six specimens dissected, sixty-three had taken food, and that the ratio of those which were eating increased rapidly the longer the fishes were kept in the aquarium. Only one-fourth of those examined on the fourteenth of the month had taken food, while more than five-sixths of those bottled ten days later had already eaten. The entire number of objects appropriated by these sixty-three fishes was as follows: *Cyclops thomasi*, ninety-seven; *Diaptomus sicilis*, seventy-eight; *Anuræa striata*, twenty-nine; *Daphnia hyalina*, one. Seven of the fishes had eaten unicellular Algæ, two had eaten diatoms, and one filamentous Algæ.

From the above data we are compelled to conclude that the earliest food of the whitefish consists almost wholly of the smallest species of Entomostraca occurring in the lake, since the other elements in their alimentary canals were evidently either taken accidentally, or else appeared in such trivial quantity as to contribute nothing of importance to their support. In fact, two species of Copepoda, *Cyclops thomasi* and *Diaptomus sicilis*, are certainly very much more important to the maintenance of the whitefish in this earliest stage of independent life than all the other organisms in the lake combined. As the fishes increase in size, vigor and activity, they doubtless enlarge their regimen by capturing larger species of Entomostraca, especially Daphnia and Limnocalanus.

A few words respecting the relative abundance of these species at different seasons of the year and their distribution in the lake will have some practical value. We may observe here an excellent illustration of the remarkable uni formity of the life of the lake as contrasted with that of smaller bodies of water. While in ponds minute animal life is largely destroyed or suspended during the winter, the opening spring being attended by an enormous increase in numbers and rate of multiplication, in Lake Michigan there is but little difference in the products of the collecting apparatus at different seasons of the year.* There is a slight increase in the number of individuals during spring and early summer, but scarcely enough appreciably to affect the food supply of fishes dependent upon them. They are not by any means equally distributed, however, throughout the lake, my own observations tending to show that there are relatively very few of these minute crustaceans to be found at a distance of a few miles from shore, and that, in fact, by far the greater part of them usually occur within a distance of two or three miles out. Indeed, the mouths of the rivers flowing into the lake are ordinarily much more densely populated by these animals than the lake itself, as has been particularly evident at Racine and South Chicago. Neither are they commonly equally distributed throughout the waters in which they are most abundant, but, like most other aquatic animals, occur in shoals. In the deeper portions of the lake many species shift their level, according to the time of day, coming to the surface by night and sinking again when the sun is bright.

These facts make it important to the fish-culturist that the particular situation when it is proposed to plant the fry should be searched at the time when these are to be liberated, to determine whether they will find at once sufficient food for their support. A little experience will easily enable one to estimate the relative abundance of the Entomostraca at any given time and place, and they require nothing for their capture more complicated or difficult of management than a simple net of cheese-cloth or similar material towed behind a boat. This may be weighted and sunk to any desired depth, so that the contents of the water either at the surface or at the bottom, may be ascertained by a few minutes' rowing.—*State Laboratory of Natural History, Champaign, Ill.*

* For definite assurance of this fact I am indebted less to my own observations (which are, however, consistent with it so far as they go), than to the statements of B. W. Thomas, Esq., of Chicago, who, while making a specialty of the Diatomaceæ of the lake, has collected and studied all its organic forms for several years, obtaining them from the city water by attaching a strainer to a hydrant many times during every month throughout the year.

7.—SOME OBSERVATIONS UPON THE GRAYLING.

BY J. C. PARKER, OF THE MICHIGAN FISH COMMISSION.

The question as to whether the grayling (*Thymallus tricolor*) could be successfully propagated artificially being practically undecided by this commission, it was decided to prepare waters as nearly in accordance with natural conditions as possible and make as careful and systematic an attempt as we could to solve it. Accordingly ponds were made on the Buck Horn creek, of just sufficient depth to admit of screening and through which the whole creek flowed, with the hope that if placed here they would in the spring—the spawning season—give us an opportunity to observe and handle them under less difficult circumstances than in their native streams. We hoped that as the Buck Horn had originally been a good grayling stream, it would place at our disposal the most advantageous conditions. The ponds being in readiness, the several members of the Michigan Fish Commission proceeded on the 20th of August to the west branch of the Manistee, fifteen miles from the railroad station at Kalkaska, with boats, cans, and camp equipage, prepared to make a week of it. The fish were to be captured with rod and line, it having been demonstrated that this was more certain, and the results more satisfactory, than any attempt to use nets of any description. The result was that at the end of the week we had caught and had in excellent condition about one hundred fine specimens. From five to six of these were put into a can, the temperature of the water—which was comparatively low—kept down by the addition of ice, and nine of these cans loaded into a lumber-wagon and the journey to the station over a bouncing corduroy road commenced. Only one opportunity to change the water en route was afforded, but, notwithstanding all this rough handling, they reached their destination with only the loss of some four or five specimens.

During the winter they were watched and cared for, but the loss was about twenty-five per cent. When the spawning season arrived a close watch was kept to see when any signs of spawn-laying should commence, but we watched in vain. So far as could be ascertained there was nothing to indicate that they had, would, or could ever spawn, and to-day we are no nearer a practical solution of the vexed question than when we commenced. During this, and a subsequent visit to the same locality, I was enabled to make some observations upon their food and their habits in feeding, which may be of interest. Near the camp was a pool in which two small fish had their haunts, one about six inches in length, and the other half the size. The larger one when at rest was on a bit of clean sand in plain view; the other lay under some sunken drift-wood, dark in color, and under which he concealed himself, only the tip of his nose being visible, and the contrast in color corresponded exactly with their resting places; the larger one was so nearly the color of the sand on which he lay as hardly to be distinguished from it; only when in motion as he arose to the surface for his food; the other was as dark as the sticks under which he lay, showing that the question of color is one of bottom locality and undoubtedly a circumstance of more or less light. I was somewhat surprised at the tenacity with which they adhered to a locality when once domiciled in it. Three or four times I drove them out of their haunts; one afternoon chasing the larger one several rods up the stream, only to find him in the same spot the next day, and when I returned to the same locality, after an absence of four weeks, I found the same fish apparently in the same places. In rising for food I never saw either of them more than a yard from their haunts, and only rarely but a few inches. They would detect their prey at a considerable distance and slowly rise to meet it as it floated to them, and then a sudden flash, and they were back to their respective resting places. The deviation from the point where they lay was, from side to side across the stream, hardly ever but a few inches up or down. One day, when they were rising with more than usual frequency, I carefully crept out on a projecting log until I was nearly over them, and could watch their every movement, and, with watch in hand, counted the "rises" of the larger one for fifteen minutes. In this time he came to the surface and secured his prey fifty times. Sometimes he would rise nearly to the surface and then slowly settle down again, but whenever he actually seized anything he was back to his haunt again with a motion so quick the eye could scarcely follow him. After considerable observation I could detect the particular insect I was sure he would rise for, sometimes before he would show any motion in that direction. Watching his quick, unerring sight, and his ability to detect what was food, and what was not, led me into some generalizations on what their food really was, that were new to me.

In eviscerating fish for any purpose, I have always been in the habit of examining the contents of the stomach, and the stomach of the grayling had always puzzled me by the quantity of vegetable matter so often found in them; but the *a priori* conclusion was that he was necessarily a carnivorous, or insectivorous fish; the thought that he was a vegetarian as well, never occurred to me. I had observed that the fronds of the white cedar—*arbor vitæ*—were quite usually among the contents of the stomach, but I had always considered it as something adventitious, an accident, occurring in the procuring of his food, and not deliberately taken. But a somewhat singular circumstance that occurred upon this last expedition staggered me somewhat. On the afternoon of the day of my arrival, after the tent was pitched, and camp life organized, I proceeded to a pool below a flooding dam near camp, thinking I could secure enough grayling for the supper of myself and little daughter, who accompanied me. I succeeded in securing two nice ones, weighing probably about six or eight ounces each, and upon dressing them and examining the stomachs as usual, judge of my surprise upon finding one of them full of oats; there were eight kernels stored away in first-class style, and my first question was, where in the name of the Prophet could they have come from, for I knew that there wasn't a spear of grain growing within a

dozen miles of this pool and the condition the grain was in showed that they could have been in the stomach but a short time. I finally solved the mystery by remembering that the man who brought us out—we arrived about noon—fed his horse some oats at a point just above the pool, and the grain was either blown into the water or carelessly thrown in by some one. I frequently found in their stomachs portions of the leaves and seeds of the water plants growing in the streams. Among the latter was in several instances a round seed about as large as a No. 4 shot, which I at first thought was a mollusk, a species of spherium, but on examining it with a glass what appeared to the naked eye to be the striations of the shell proved to be the veination of the seed. It may be urged against the vegetarian theory that many fish take that which in no way resembles their ordinary food, as the artificial fly and the different varieties of spoon and spinning baits, and that this particular fish could in no way have had any previous knowledge of oats as food, and consequently the taking of it must be in the nature of a freak rather than a habit, but I do not remember to have ever found in the stomachs of other fish any substance other than their food but which could be accounted for as accidental, while in the grayling the presence of vegetable matter in some forms is of so frequent an occurrence as to point strongly to the fact, that a part of their food at least is vegetable.

Another point in favor of this theory is the peculiar flavor of the fish and that which has given it its specific name. It is a well-known fact that the flesh of all animals is to a greater or less degree flavored by its food. Now, if this fish fed upon exactly the same materials as the brook trout, could there be a reasonable doubt but what its flesh would taste like that of the trout, while the fact is, that it is distinctly different.

You are probably aware of the difference between a liverfed trout and one caught in its native wilds; a difference so patent, that a person relying upon the taste alone would pronounce them an entirely different fish. One thing is certain, whatever its food is, it must have existed in unlimited quantities to have supported such a large multitude of this fish as absolutely swarmed in the northern streams of this State at an early day. D. A. Blodget, now living at Grand Rapids (and one of the pioneers of the Muskegon at the Hersey-branch), told me that when he first built a dam at the mouth of this stream, that in the spring, during the spawning season, when the grayling were trying to find their way to the spawning grounds, that he has seen the inhabitants fill the box of a common lumber wagon full of this fish in a few hours and carry them out into the country, not only one such load, but half a dozen of each spring for several successive years, while as many more must have been taken away in smaller quantities, and he estimated the quantity taken by tons each year; that during the first winter he spent there, he supplied his table with this fish by taking a common nail-rod and sharpening it with his ax, and cutting a barb on it with the same tool, and going to any of the bends in the stream, and cutting a hole in the ice, he could in a little while get all he wanted by thrusting this primitive spear at random into the waters beneath; and as the number of fish that any stream can furnish is to a great extent limited only by the food supply, it seems that so great a number as was then found, not only in this particular stream, but in most all the streams in which they were found, must have had some food in much greater abundance than what is usually found in our ordinary trout streams.—*Grand Rapids, Mich.*

8.—THE DISTRIBUTION OF FRESH-WATER FISHES.

BY PROF. DAVID STARR JORDAN.

When I was a boy and went fishing in the brooks of western New York, I noticed that the different streams did not always have the same kinds of fishes in them. Two streams in particular in Wyoming county, not far from my father's farm, engaged in this respect my special attention. Their sources are not far apart, and they flow in opposite directions, on opposite sides of a low ridge—an old glacial moraine, something more than a mile across. The Oatka creek flows northward from this ridge, while the East Coy runs toward the southeast on the other side of it, both flowing ultimately into the same river, the Genesee.

It does not require a very careful observer to see that in these two streams the fishes are not quite the same. The streams themselves are similar enough. In each the waters are clear and fed by springs. Each flows over gravel and clay, through alluvial meadows, in many windings, and with elms and alders "in all its elbows." In both streams we were sure of finding trout (*Salvelinus fontinalis* Mitchill), and in one of them the trout are still abundant. In both we used to catch the brook chub (*Semotilus atromaculatus* Mitchill), or as we called it, the "horned dace;" and in both were large schools of shiners (*Notropis megalops* Rafinesque) and of suckers (*Catostomus teres* Mitchill). But in every deep hole, and especially in the mill-ponds along the East Coy creek, the horned pout (*Ameiurus melas* Rafinesque) swarmed on the mucky bottoms. In every eddy, or in the deep hole worn out at the root of the elm trees, could be seen the sunfish (*Lepomis gibbosus* Linnæus), strutting in green and scarlet, with spread fins keeping intruders away from its nest. But in the Oatka creek were found neither horned pout nor sunfish, nor have I ever heard that either has been taken there. Then besides these nobler fishes, worthy of a place on every school-boy's string, we knew by sight, if not by name, numerous smaller fishes, darters (*Etheostoma flabellare* Rafinesque) and minnows (*Rhinichthys atronasus* Mitchill), which crept about in the gravel on the bottom of the East Coy, but which we never recognized in the Oatka.

There must be a reason for differences like these, in the streams themselves or in the nature of the fishes. The sunfish and the horned pout are home-loving fishes to a greater extent than the others which I have mentioned; still, where no obstacles prevent, they are sure to move about. There must be, then, in the Oatka some sort of a barrier, or strainer, which keeping

these species back permits others more adventurous to pass; and a wider knowledge of the geography of the region showed that such is the case. Farther down in its course, the Oatka falls over a ledge of rock, forming a considerable waterfall at Rock Glen. Still lower down its waters disappear in the ground, sinking into some limestone cavern or gravel-bed, from which they reäppear, after some six miles, in the large springs at Caledonia. Either of these barriers might well discourage a quiet-loving fish; while the trout and its active associates have sometime passed them, else we should not find them in the upper waters in which they alone form the fish-fauna. This problem is a simple one; a boy could work it out, and the obvious solution seems to be satisfactory.

Since those days I have been a fisherman in many waters—not an angler exactly, but one who fishes for fish, and to whose net nothing large or small ever comes amiss; and wherever I go I find cases like this.

We do not know all the fishes of America yet, nor all those well that we know by sight; still this knowledge will come with time and patience, and to procure it is a comparatively easy task. It is also easy to ascertain the more common inhabitants of any given stream. It is difficult, however, to obtain negative results which are really results. You cannot often say that a species does not live in a certain stream. You can only affirm that you have not yet found it there, and you can rarely fish in any stream so long that you can find nothing that you have not taken before. Still more difficult is it to gather the results of scattered observations into general statements regarding the distribution of fishes. The facts may be so few as to be misleading, or so numerous as to be confusing; and the few writers who have taken up this subject in detail have found both these difficulties to be serious. Whatever general proposition we may maintain must be stated with the modifying clause of "other things being equal;" and other things are never quite equal.

Still less satisfactory is our attempt to investigate the causes on which our partial generalizations depend—to attempt to break to pieces the "other things being equal" which baffle us in our search for general laws.

We now recognize about six hundred species of fishes as found in the fresh waters of North America, north of the Tropic of Cancer, these representing thirty-four of the natural families. As to their habits, we can divide these species rather roughly into the four categories proposed by Professor Cope, or, as we may call them—

(1) Lowland fishes; as the bow-fin, pirate perch, large-mouthed black bass, sunfishes and some catfishes.

(2) Channel fishes; as the channel catfish, the moon-eye, gar pike, buffalo fishes and drum.

(3) Upland fishes; as many of the darters, shiners and suckers, and the small-mouthed black bass.

(4) Mountain fishes; as the brook trout, and many of the darters and minnows.

To these we may add the more or less distinct classes of (5) Lake fishes, inhabiting only waters which are deep, clear and cold, as the various species of whitefish and the great lake trout; (6) Anadromous fishes, or those which run up from the sea to spawn in fresh waters, as the salmon, sturgeon, shad and striped bass; (7) Catadromous fishes, like the eel, which pass down to spawn in the sea; (8) Brackish-water fishes, which thrive best in the debatable waters of the river-mouths, as most of the sticklebacks and the killifishes.

As regords the range of the species, we have every possible gradation from those which seem to be confined to a single river, and are rare even in their restricted habitat, to those which are in a measure cosmopolitan,* ranging everywhere in suitable waters.

Still, again, we have all degrees of constancy and inconstancy in what we regard as the characters of a species. Those found only in a single river basin are usually uniform enough; but the species having a wide range usually vary much in different localities. Continued explorations bring to light from year to year, new species; but the number of new forms now discovered each year is usually less than the number of recognized species which are yearly proved to be intenable. Three complete lists of the fresh-water fishes of the United States have been published by the present writer. That of Jordan and Copeland, † published in 1876, enumerates 670 species. That of Jordan ‡ in 1878 contains 665 species, and that of Jordan § in 1885, 587 species, although upwards of 75 new species were detected in the nine years which elapsed between the first and the last list. Additional specimens from intervening localities are often found to form connecting links among the nominal species, and thus several supposed species become in time merged in one. Thus the common channel catfish (*Ictalurus punctatus* Rafinesque) of our rivers has been described as a new species not less than twenty-five times, on account of differences, real or imaginary, but comparatively trifling in value.

Where species can readily migrate, their uniformity is preserved; but whenever a form becomes localized its representatives assume some characters not shared by the species as a whole.

Comparing a dozen fresh specimens of almost any kind of fish from any body of water with an equal number from somewhere else, one will rarely fail to find some sort of differences—in size, in form, in color. These differences are obviously the reflex of differences in the environment, and the collector of fishes seldom fails to recognize them as such; often it is not difficult to refer the effect to the conditions. Thus, fishes from grassy bottoms are darker than those taken from over sand, and those from a bottom of muck are darker still, the shade of color being, in some way not well understood, dependent on the color of the surroundings. Fishes in large bodies of water reach a larger size than the same species in smaller streams or ponds. Fishes from foul or sediment laden waters are paler in color and slenderer in form than those from waters which are clear and pure. Again, it is often true that specimens from northern waters are often less slender in body than those from farther south; and so on. Other things being equal, the more remote the localities from each other, the greater are these differences.

It is evident, from these and other facts, that the idea of a separate creation for each species of fishes in each river basin, as entertained by Agassiz, is wholly incompatible with our present knowledge of the specific distinctions or of the geographical distribution of fishes. This is an unbroken gradation

* Thus the chub-sucker (*Erimyzon sucetta*) in some of its varieties ranges everywhere from Maine to Dakota, Florida and Texas; while a number of other species are scarcely less widely distributed.

† Check List of the Fishes of the Fresh Waters of North America, by David S. Jordan and Herbert E. Copeland. Bulletin of the Buffalo Society of Natural History, 1876, pp. 133-164.

‡ A Catalogue of the Fishes of the Fresh Waters of North America. Bulletin of the United States Geological Survey, 1878, pp. 407-442.

§ A Catalogue of the Fishes known to inhabit the Waters of North America North of the Tropic o Cancer. Annual Report of the Commissioners of Fish and Fisheries for 1884 and 1885.

in the variations from the least to the greatest—from the peculiarities of the individual, through local varieties, geographical sub-species, species, sub-genera, genera, families, super-families, and so on, until all fish-like vertebrates are included in a single bond of union.

It is, however, evident that not all American types of fishes had their origin in America, or even first assumed in America their present forms. Some of these are perhaps immigrants from Northern Asia, where they still have their nearest relatives. Still others are evidently modified importations from the sea; and of these some are very recent immigrants, land-locked species which have changed very little from the parent stock.

We can say, in general, that in all waters not absolutely uninhabitable there are fishes. The processes of natural selection have given to each kind of river or lake species of fishes adapted to the conditions of life which obtain there. There is no condition of water, of bottom, of depth, of speed of current, but finds some species with characters adjusted to it. These adjustments are, for the most part, of long standing; and the fauna of any single stream has, as a rule, been produced by immigration from other regions or from other streams. Each species has an ascertainable range of distribution, and within this range we may be reasonably certain to find it in any suitable waters.

But every species has beyond question some sort of limit to its distribution, some sort of barrier which it has never passed in all the years of its existence. That this is true becomes evident when we compare the fish-faunæ of widely separated rivers. Thus the Sacramento, Connecticut, Rio Grande and St. John's rivers have not a single species in common; and with one or two exceptions, not a species is common to any two of them. None of these has any species peculiar to itself, and each shares a large part of its fish-fauna with the water-basin next to it. It is probably true that the faunæ of no two distinct hydrographic basins are wholly identical, while, on the other hand, there are very few species confined to a single one. The supposed cases of this character, some twenty in number, occur chiefly in the streams of the South Atlantic States and of Arizona. All of these need, however, the confirmation of further exploration. It is certain that in no case has an entire river fauna originated independently from the divergence into separate species of the descendants of a single type.

The existence of boundaries to the range of species implies, therefore, the existence of barriers to their diffusion. We may now consider these barriers, and in the same connection, the degree to which they may be overcome.

Least important of these are the barriers which may exist within the limits of any single basin, and which tend to prevent a free diffusion through its waters of species inhabiting any portion of it. In streams flowing southward, or across different parallels of latitude, the difference in climate becomes a matter of importance. The distribution of species is governed very largely by the temperature of the water. Each species has its range in this respect—the free-swimming fishes, notably the trout, being most affected by it; the mud loving or bottom fishes, like the catfishes, least. The latter can reach the cool bottoms in hot weather, or the warm bottoms in cold weather, thus keeping their own temperature more even than that of the surface of the water. Although water communication is perfectly free for most of the length of the Mississippi, there is a material difference between the faunæ of the stream in Minnesota and in Louisiana. This difference is caused chiefly by the difference in temperature occupying the difference in latitude. That a similar difference of longitude, with free water communication, has no appreciable importance, is shown by the almost absolute identity of the fish-faunæ of Lake Winnebago and Lake Champlain. While many large fishes range freely up and down the Mississippi, a majority of the species do not do so, and the fauna of the upper Mississippi has more in common with that of the tributaries of Lake Michigan than it has with that of the Red River or the Arkansas. The influence of the climate is again shown in the paucity of the fauna of the cold waters of Lake Superior, as compared with that of Lake Michigan. The majority of our species cannot endure the cold. In general therefore, cold or Northern waters contain fewer species than Southern waters do, though the number of individuals of any one kind may be greater. This is shown in all waters, fresh or salt. The fisheries of the Northern seas are more extensive than those of the Tropics. There are more fishes there, but they are less varied in kind. The writer once caught seventy-five species of fishes in a single haul of the seine at Key West, while on Cape Cod he obtained with the same net but forty-five species in the course of a week's work. Thus it comes that the angler, contented with many fishes of few kinds, goes to Northern streams to fish, while the naturalist goes to the South.

But in some streams the difference in latitude is significant, and the chief differences in temperature come from differences in elevation, or from the distance of the waters from the colder source. Often the lowland waters are so different in character as to produce a marked change in the quality of their fauna. These lowland waters may form a barrier to the free movements of upland fishes; but that this barrier is not impassable is shown by the identity of the fishes in the streams (for example, Elk river, Duck river, etc.) of the uplands of middle Tennessee with those of the Holston and French Broad. Again, streams of the Ozark mountains, similar in character to the rivers of East Tennessee, have an essentially similar fish-fauna, although between the Ozarks and the Cumberland range lies an area of lowland bayous, into which such fishes are never known to penetrate. We can, however, imagine that these upland fishes may be sometimes swept down from one side or the other into the Mississippi, from which they might ascend on the other side. But such transfers certainly do not often happen. This is apparent from the fact that the two faunæ* are not quite identical, and in some cases the same species are represented by perceptibly different varieties on one side and the other. The time of the commingling of these faunæ is perhaps now past, and it may have occurred only when the climate of the intervening regions was colder than at present.

The effect of waterfalls and cascades as a barrier to the diffusion of most species is self-evident; but the importance of such obstacles is less, in the course of time, than might be expected. In one way or another very many species have passed these barriers. The falls of the Cumberland limit the range of most of the larger fishes of the river, but the streams above it have their quota of darters and minnows. It is evident that the past history of the stream must enter as a factor into this discussion, but this past history it

*There are three species of darters (*Ethcostoma copelandi* Jordan; *Ethcostoma evides* Jordan and Copeland; *Ethcostoma scierum* Swain) which are now known only from the Ozark region or beyond and from the uplands of Indiana, not yet having been found at any point between Indiana and Missouri. These constitute perhaps isolated colonies, now separated from the parent stock in Arkansas by the prairie districts of Illinois, a region at present uninhabitable for these fishes. But the non-occurrence of these species over the intervening areas needs confirmation, as do most similar cases of anomalous distribution.

is not always possible to trace. Dams or artificial waterfalls now check the free movement of many species, especially those of migratory habits; while, conversely, numerous other species have extended their range through the agency of canals (thus, *Dorosoma cepedianum* Le Sueur, and *Clupea chrysochloris* Rafinesque, have found their way into Lake Michigan through canals).

Every year fishes are swept down the rivers by the winter's floods; and in the spring, as the spawning season approaches, almost every species is found working its way up the stream. In some cases, notably the Quinnat salmon (*Oncorhynchus tschawytscha* Walbaum) and the blueback salmon (*Oncorhynchus nerka* Walbaum), the length of these migrations is surprisingly great. To some species rapids and shallows have proved a sufficient barrier, and other kinds have been kept back by unfavorable conditions of various sorts. Streams whose waters are always charged with silt or sediment, as the Missouri, Arkansas, or Brazos, do not invite fishes; and even the occasional floods of red mud such as disfigure otherwise clear streams, like the Red river or the Colorado (of Texas), are unfavorable. Extremely unfavorable also is the condition which obtains in many rivers of the Southwest; as for example, the Red river, the Sabine, and the Trinity, which are full from bank to bank in winter and spring, and which dwindle to mere rivulets in the autumn droughts.

In general, those streams which have conditions most favorable to fish-life will be found to contain the greatest number of species. Such streams invite immigration; and in them the struggle for existence is individual against individual, species against species, and not a mere struggle with hard conditions of life. Some of the conditions most favorable to the existence in any stream of a large number of species of fishes are the following, the most important of which is the one mentioned first: Connection with a large hydrographic basin; a warm climate; clear water; a moderate current; a bottom of gravel (preferably covered by a growth of weeds); little fluctuation during the year in the volume of the stream or in the character of the water.

Limestone streams usually yield more species than streams flowing over sandstone, and either more than the streams of regions having metamorphic rocks. Sandy bottoms usually are not favorable to fishes. In general, glacial drift makes a suitable river bottom, but the higher temperature usual in regions beyond the limits of the drift gives to certain southern streams conditions still more favorable. These conditions are all well realized in the Washita river in Arkansas, and in various tributaries of the Tennessee, Cumberland and Ohio; and in these, among American streams, the greatest number of species has been recorded.

The isolation and the low temperature of the rivers of New England have given to them a very scanty fish-fauna as compared with the rivers of the south and west. This fact has been noticed by Professor Agassiz, who has called New England a "zoölogical island." *

In spite of the fact that barriers of every sort are sometimes crossed by fresh-water fishes, we must still regard the matter of freedom of water communication as the essential one in determining the range of most species. The larger the river basin, the greater the variety of conditions likely to

*" In this isolated region of North America, in this zoological island of New England, as we may call it, we find neither Lepidosteus, nor Amia, nor Polyodon, nor Amblodon (*Aplodinotus*), nor Grystes (*Micropterus*), nor Centrarchus, nor Pomoxis, nor Amploplites nor Calliurus, (*Chænobryttus*), nor Carpiodes, nor Hyodon, nor indeed any of the characteristic forms of North American fishes so common everywhere e se, with the exception of two Pomotis (*L pomis*), one Boleosoma, and a few Catostomus."—AGASSIZ, *Amer. Journ. Sci. Arts*, 1854.

be offered in it, and the greater the number of its species. In case of the divergence of new forms by the processes called "natural selection," the greater the number of such forms which may have spread through its waters; the more extended any river basin, the greater are the chances that any given species may sometime find its way into it; hence the greater the number of species that actually occur in it, and, freedom of movement being assumed, the greater the number of species to be found in any one of its affluents.

Of the six hundred species of fishes found in the rivers of the United States, about two hundred have been recorded from the basin of the Mississippi. From fifty to one hundred of these species can be found in any one of the tributary streams of the size, say, of the Housatonic river or the Charles. In the Connecticut river there are about eighteen species permanently resident; and the number found in the streams of Texas is not much larger, the best-known of these, the Rio Colorado, having yielded but twenty-four species.

The waters of the great basin have not yet been fully explored. The number of species now known from this region is about seventy-five. This number includes the fauna of the upper Rio Grande, the Snake river, and the Colorado, as well as the fishes of the tributaries of the great Salt Lake. This list is composed almost entirely of a few genera of suckers (*Catostomus, Pantosteus, Chasmistes*), minnows, (*Squalius, Gila, Ptychocheilus*, etc), and trout (*Salmo mykiss* and its varieties). None of the catfishes, perch, darters, or sunfishes, mooneyes, killifishes, and none of the ordinary eastern types of minnows (genera *Notropis, Chrosomus*, etc.) have passed the barrier of the Rocky Mountains.

West of the Sierra Nevada, the fauna is still more scanty, but fifty species being enumerated. This fauna, except for certain immigrants (as the fresh water surf-fish [*Hysterocarpus traski*] and the species of salmon) from the sea, is of the same general character as that of the great basin, though most of the species are different. This latter fact would indicate a considerable change, or "evolution," since the contents of the two faunæ were last mingled. There is a considerable difference between the fauna of the Columbia and that of the Sacramento. The species which these two basins have in common are chiefly those which at times pass out into the sea. The rivers of Alaska contain but few species, barely a dozen in all, most of these being found also in Siberia and Kamtschatka. In the scantiness of its faunal list, the Yukon agrees with the Mackenzie river, and with Arctic rivers generally.

There can be no doubt that the general tendency is for each species to extend its range more widely until all localities suitable for its growth are included. The various agencies of dispersal which have existed in the past are still in operation. There is apparently no limit to their action. It is probable that new "colonies" of one species or another may be planted each year in waters not heretofore inhabited by such species. But such colonies become permanent only where the conditions are so favorable that the species can hold its own in the struggle for food and subsistence. That various modifications in the habitat of certain species have been caused by human agencies is of course too well known to need discussion here.

We may next consider the question of water-sheds or barriers which separate one river basin from another.

Of such barriers in the United States, the most important and most effective is unquestionably that of the main chain of the Rocky Mountains. This

is due in part to its great height, still more to its great breadth, and most of all, perhaps, to the fact that it is nowhere broken by the passage of a river. But two species—the red-throated or Rocky Mountain trout (*Salmo mykiss* Walbaum [=*purpuratus* Pallas]) and the Rocky Mountain whitefish (*Coregonus williamsoni* Girard)—are found on both sides of it, at least within the limits of the United States; while many genera, and even several families, find in it either an eastern or a western limit to their range. In a few instances representative species, probably modifications or separated branches of the same stock, occur on opposite sides of the range, but there are not many cases of correspondence even thus close.

It is easy to account for the separation of the faunæ; but how shall we explain the almost universal diffusion of the whitefish and the trout in suitable waters on both sides of the dividing ridge? We may notice that these two are the species which ascend highest in the mountains, the whitefish inhabiting the mountain pools and lakes, the trout ascending all brooks and rapids in search of their fountain-heads. In many cases the ultimate dividing ridge is not very broad, and we may imagine that at some time spawn or even young fishes may have been carried across by birds or other animals or by man—or more likely by the dash of some summer whirlwind. Once carried across in favorable circumstances, the species might survive and spread.

I have seen an example of how such transfer of species may be accomplished, which shows that we need not be left to draw on the imagination to invent possible means of transit.

There are few water-sheds in the world better defined than the mountain range which forms the "backbone" of Norway. I lately climbed a peak in this range, the Suletind. From its summit I could look down into the valleys of the Lära and the Bägna, flowing in opposite directions to opposite sides of the peninsula. To the north of the Suletind is a large double lake called the Sletningenvand. The maps show this lake to be one of the chief sources of the westward-flowing river Lära. This lake is in August swollen by the melting of the snows, and at the time of my visit it was visibly the source of both these rivers. From its southeastern side flowed a large brook into the valley of the Bägna, and from its southwestern corner, equally distinctly, came the waters which fed the Lära. This lake, like similar mountain ponds in all northern countries, abounds in trout; and these trout certainly have for part of the year an uninterrupted line of water communication from the Sognefjord on the west of Norway to the Christianiafjord on the south-east—from the North Sea to the Baltic. Part of the year the lake has probably but a single outlet through the Lära. A higher temperature would entirely cut off the flow into the Bägna, and a still higher one might dry up the lake altogether. This Sletningenvand,* with its two outlets on the summit of a sharp water-shed, may serve to show us how other lakes, permanent or temporary, may elsewhere have acted as agencies for the transfer of fishes. We can also see how it might be that certain mountain fishes

* Since the above was written I have been informed by Professor John M. Coulter, who was one of the first explorers of the Yellowstone Park, that such a condition still exists on the Rocky Mountain Divide. In the Yellowstone Park is a marshy tract, traversable by fishes in the rainy season, and known as the "Two-Ocean Water." In this tract rise tributaries both of the Snake river and of the Yellowstone. Similar conditions apparently exist on other parts of the Divide, both in Montana and in Wyoming.

Professor John C. Branner calls my attention to a marshy upland which separates the valley of the La Plata from that of the Amazon, and which permits the free movement of fishes from the Paraguay river to the Tapajos. It is well known that through the Cassiquiare river the Rio Negro, another branch of the Amazon, is joined to the Orinoco river. It is thus evident that almost all the waters of eastern South America form a single basin, so far as the fishes are concerned.

should be so transferred while the fishes of the upland waters may be left behind. In some such way as this we may imagine the trout and the whitefish to have attained their present wide range in the Rocky Mountain region; and in similar manner perhaps the Eastern brook trout (*Salvelinus fontinalis* Mitchill) and some other mountain species (*Notropis rubricroceus* Cope; *Rhinichthys atronasus* Mitchill, etc.) may have been carried across the Alleghanies.

The Sierra Nevada constitutes also a very important barrier to the diffusion of species. This is, however, broken by the passage of the Columbia river, and many species thus find their way across it. That the waters to the west of it are not unfavorable for the growth of eastern fishes is shown by the fact of the rapid spread of the common eastern catfish (*Ameiurus nebulosus* Le Sueur) or horned pout, when transported from the Schuylkill to the Sacramento. This fish is now one of the important food fishes of the San Francisco markets. It has become in fact, an especial favorite with the Chinaman—himself also an immigrant, and presenting certain analogies with the fish in question, as well in temperament as in habits.

The mountain mass of Mount Shasta is as already stated, a considerable barrier to the range of fishes, though a number of species find their way around it through the sea. The lower and irregular ridges of the Coast Range are of small importance in this regard, as the streams of their east slope reach the sea on the west through San Francisco Bay. Yet the San Joaquin contains a few species, not yet recorded, from the smaller rivers of southwestern California.

The main chain of the Alleghanies forms a barrier of importance separating the rich fish-fauna of the Tennessee and Ohio basins from the scantier faunæ of the Atlantic streams. Yet this barrier is crossed by many more species than is the case with either the Rocky Mountains or the Sierra Nevada. It is lower, narrower, and much more broken—as in New York, in Pennsylvania, and in Georgia there are several streams which pass through it or around it. The much greater age of the Alleghany chain, as compared with the Rocky Mountains, seems not to be an element of any importance in this connection. Of the fish which cross this chain, the most prominent is the brook trout (*Salvelinus fontinalis*), which is found in all suitable waters from Hudson's Bay to the head of the Chattahoochee. A few other species are locally found in the headwaters of certain streams on opposite sides of the range. An example of this is the little red "fall fish" (*Notrobis rubicroceus* Cope), found only in the mountain tributaries of the Savannah and the Tennessee. We may suppose the same agencies to have assisted these species that we have imagined in the case of the Rocky Mountain trout, and such agencies were doubtless more operative in the times immediately following the glacial epoch than they are now.

The passage of species from stream to stream along the Atlantic slope deserves a moment's notice. It is, under present conditions, impossible for any mountain or upland fish, as the trout or the miller's thumb (*Cottus richardsoni* Agassiz), to cross from the Potomac river to the James, or from the Neuse to the Santee, by descending to the lower courses of the rivers, and thence passing along either through the swamps or by way of the sea. The lower courses of these streams, warm and muddy, are uninhabitable by such fishes. Such transfers are, however, possible farther north. From the rivers of Canada and from many rivers of New England the trout does descend to

the sea and into the sea, and farther north the whitefish does this also. Thus these fishes readily pass from one river basin to another. As this is the case now everywhere in the North, it may have been the case farther south in the time of the glacial cold. We may, I think, imagine a condition of things in which the snow fields of the Alleghany chain might have played some part in aiding the diffusion of cold-loving fishes. A permanent snow-field on the Blue Ridge in western North Carolina might render almost any stream in the Carolinas suitable for trout, from its source to its mouth. An increased volume of colder water might carry the trout of the head-streams of the Catawba and the Savannah as far down as the sea. We can even imagine that the trout reached these streams in the first place through such agencies, though of this there is no positive evidence. For the presence of trout in the upper Chattahoochee, we must account in some other way.

It is noteworthy that the upland fishes are nearly the same in all these streams, until we reach the southern limit of possible glacial influence. South of western North Carolina, the faunæ of the different river basins appear to be more distinct from one another. Certain ripple-loving types* are represented by closely related but unquestionably different species in each river basin, and it would appear that a thorough mingling of the upland species in these rivers has never taken place.

With the lowland species of the southern rivers it is different. Few of these are confined within narrow limits. The streams of the whole South Atlantic and Gulf Coast flow into shallow bays, mostly bounded by sand-pits or sand-bars which the rivers themselves have brought down. In these bays the waters are often neither fresh nor salt; or rather, they are alternately fresh and salt, the former condition being that of the winter and spring. Many species descend into these bays, thus finding every facility for transfer from river to river. There is a continuous inland passage in fresh or brackish waters, traversable by such fishes, from Chesapeake Bay nearly to Cape Fear; and similar conditions exist on the coasts of Louisiana, Texas and much of Florida. In Perdido Bay I have found fresh-water minnows (*Notropis cercostigma; Notropis xænocephalus*), and silversides (*Labidesthes sicculus*), living together with marine gobies (*Gobiosoma molestum*) and salt-water eels (*Myrophis punctatus*). Fresh-water alligator gars (*Lepisosteus tristœchus*) and marine sharks compete for the garbage thrown over from the Pensacola wharves. In Lake Pontchartrain the fauna is a remarkable mixture of fresh-water fishes from the Mississippi and marine fishes from the Gulf. Channel-cats, sharks, sea-crabs, sunfishes and mullets can all be found there together. It is therefore to be expected that the lowland fauna of all the rivers of the Gulf States would closely resemble that of the lower Mississippi; and this, in fact, is the case.

The low and irregular water-shed which separates the tributaries of Lake Michigan and Lake Erie from those of the Ohio is of little importance in

*The best examples of this are the following: In the Santee basin are found *Notropis pyrrhomelas*,
Notropis niveus, and *Notropis chloristius*; in the Altamaha, *Notropis xænurus* and *Notropis callisemus*;
in the Chattahoochee, *Notropis hypselopterus* and *Notropis eurystomus*; in the Alabama, *Notropis*
cæruleus, *Notropis trichroistius*, and *Notropis callistius*. In the Alabama, Escambia, Pearl and nu-
merous other rivers, is found *Notropis cercostigma*. This species descends to the sea in the cool
streams of the pine-woods. Its range is wider than that of the others, and in the rivers of Texas it
reappears in the form of a scarcely distinct variety, *Notropis venustus*. In the Tennessee and Cum-
berland, and in the rivers of the Ozark range, is *Notropis galacturus*; and in the upper Arkansas
Notropis camurus—all distinct species of the same general type. Northward, in all the streams
from the Potomac to the Oswego, and westward to the Des Moines and the Arkansas occurs a single
species of this type, *Notropis whipplei*. But this species is not known from any of the streams
inhabited by any of the other species mentioned, although very likely it is the parent stock of
them all.

determining the range of species. Many of the distinctively northern fishes are found in the head-waters of the Wabash and Scioto. The considerable difference in the general fauna of the Ohio Valley as compared with that of the streams of Michigan is due to the higher temperature of the former region, rather than to any existing barriers between the river and the Great Lakes. In northern Indiana the water-shed is often swampy, and in many places large ponds exist in the early spring.

At times of heavy rains many species will move through considerable distances by means of temporary ponds and brooks. Fishes that have thus emigrated often reach places ordinarily inaccessible, and people finding them in such localities often imagine that they have "rained down." Once, near Indianapolis, after a heavy shower, I found in a furrow in a corn-field a small pike (*Esox vermiculatus* Le Sueur), some half a mile from the creek in which he should belong. The fish was swimming along in a temporary brook, apparently wholly unconscious that he was not in his native stream. Migratory fishes, which ascend small streams to spawn, are especially likely to be transferred in this way. By some such means any of the water-sheds in Ohio, Indiana, or Illinois may be passed.

It is certain that the limits of Lake Erie and Lake Michigan were once more extended than now. It is reasonably probable that some of the territory now drained by the Wabash and the Illinois was once covered by the waters of Lake Michigan. The cisco (*Coregonus artedi sisco*, Jordan), of Lake Tippecanoe, Lake Geneva, and the lakes of the Oconomowoc chain, is evidently a modified descendant of the so-called lake herring (*Coregonus artedi* Le Sueur). Its origin most likely dates from the time when these small deep lakes of Indiana and Wisconsin were connected with Lake Michigan. The changes in habits which the cisco has undergone are considerable. The changes in external habits are but trifling. The presence of the cisco in these lakes and its periodical disappearance—that is retreat into deep water when not in the breeding season—has given rise to such nonsensical discussion as to whether any or all of these lakes are still joined to Lake Michigan by subterranean channels. Several of the larger fishes, properly characteristic of the Great Lake region (as, *Lota lota maculosa; Percopsis guttatus; Esox masquinongy*), are occasionally taken in the Ohio river, where they are usually recognized as rare stragglers. The difference in physical conditions is prob ably the sole cause of their scarcity in the Ohio basin.

The similarity of the fishes in the different streams and lakes of the Great Basin is doubtless to be attributed to the general mingling of their waters which took place during and after the glacial epoch. Since that period the climate in that region has grown hotter and drier, until the overflow of the various lakes into the Columbia basin through the Snake river has long since ceased. These lakes have become isolated from each other, and many of them have become salt or alkaline and therefore uninhabitable. In some of these lakes certain species may now have become extinct which still remain in others. In some cases, perhaps, the differences in surrounding may have caused divergence into distinct species of what was once one parent stock. The suckers in Lake Tahoe (*Catostomus tahoensis*, in Lake Tahoe; *Catostomus macrocheilus* and *discobolus*, in the Columbia; *Catostomus fecundas, Catostomus ardens*; *Chasmistes liorus* and *Pantosteus generosus* in Utah Lake) and those in Utah Lake are certainly now different from each other and from those in the Columbia. The trout (*Salma mykiss*, et vars. *henshawi* and *virginalis*) in the same waters can be regarded as more or less tangible varieties only, while the whitefishes (*Coregonus Williamsoni*) show no differences at all. The differences in the present faunæ of Lake Tahoe and Utah Lake must be chiefly due to influences which have acted since the glacial epoch, when the whole Utah basin was part of the drainage of the Columbia.

To certain species of upland or mountain fishes, the depression of the Mississippi basin itself forms a barrier which cannot be passed. The black-spotted trout (*Salmo fario* L., in Europe; *Salmo labrax* Pallas, etc., in Asia; *Salmo gairdneri* Richardson, in streams of the Pacific Coast. *Salmo mykiss* Walbaum, in Kamtschatska, Alaska, and throughout the Rocky Mountain range to the Mexican boundary, and the headwaters of the Kansas, Platte, and Missouri), very closely related species of which abound in all waters of Northern Asia, Europe, and western North America, has nowhere crossed the basin of the Mississippi, although one of its species finds no difficulty in passing Behring Strait. The trout and whitefish of the Rocky Mountain region are all species different from those of the Great Lakes or the streams of the Alleghany system. To the grayling, the trout, the whitefish, the pike, and to arctic and sub-arctic species generally, Behring Strait has evidently proved no serious obstacle to diffusion; and it is not unlikely that much of the close resemblance of the fresh-water faunæ of northern Europe, Asia and North America is due to this fact. To attempt to decide from which side the first migration came in regard to each group of fishes might be interesting; but without a wider range of facts than is now in our possession, such attempts would be mere guesswork and without value. The interlocking of the fish-faunæ of Asia and North America presents, however, a number of interesting problems, for numerous migrations in both directions have doubtless taken place.

I could go on indefinitely with the discussion of special cases, each more or less interesting or suggestive in itself, but the general conclusion is in all cases the same.

The present distribution of fishes is the result of long-continued action of forces still in operation. The species have entered our waters in many invasions from the Old World, or from the sea. Each species has been subjected to the various influences implied in the term natural selection, and under varying conditions, its representatives have undergone many different modifications.

Each of the 600 species we now know is making every year inroads on territory occupied by other species. If these colonies are able to hold their own in the struggle for possession, they will multiply in the new conditions and the range of the species will become widened. If the surroundings are different new species or varieties may be formed in time and these new forms may again invade the territory of the parent species. Again colony after colony of species after species may be destroyed by other species or uncongenial surroundings.

The ultimate result of centuries on centuries of the restlessness of individuals is seen in the facts of geographical distribution. Only in the most general way can the history of any species be traced. Could we know it all, it would be as long and as eventful a story as the history of the colonization and settlement of North America by immigrants from Europe.

By the fishes each river in America has been a hundred times discovered; its colonization a hundred times attempted. In these efforts there is no co-operation. Every individual is for himself, every struggle is a struggle of life and death. Each fish is a cannibal, and to each species each member of every other species is an alien and a savage. Now all this has a practical side to it, although the practical side has been as yet little developed.

A leading feature of the work of the Fish Commissions must be to help the fishes over the barriers, to assist nature in the direction of colonizing streams and lakes with fishes which are good to eat, to the exclusion of the kinds of which man can make no use.

This help may be given by the introduction of vigorous kinds of fishes into waters into which they had been unable to find an entrance before. The work judiciously done may be of the greatest value to the people of our country. Numerous as are the food fishes of the Mississippi valley, it must be confessed that the rank of the great bulk of them is not high. Our rivers ought to raise something better than suckers, paddle-fish, drum and buffaloes. To bring in better fishes with success, it is necessary for us to know something of the habits and necessities of the species in question, and also something definite as to the character of the waters which are to be stocked. It is of no use to plant brook trout in a muddy bayou, or channel-cat in mountain springs of ice-water, or codfish in Lake Michigan.

Most of our information in these respects is still very vague, and most attempts at the introduction of species into new waters are still of the most haphazard sort. The recent series of examinations of the Michigan lakes, lately undertaken by the Michigan State Fish Commission, ought to yield some results in this connection, yet as the character of the waters of the state is essentially uniform, what is true of one of the little lakes in the way of supporting fish life, must be largely true of all. For this reason, desirable as an extended exploration is from an economic standpoint, it can be made more important to the science of ichthyology, than to the art of fish-culture. To ichthyology, as has been said, a sculpin is as valuable as a codfish, but fish-culture prefers the codfish.

The results of a careful survey would give us facts regarding the distribution of minnows, darters and sunfish, facts of the greatest interest and importance in science, but of no value to fish-culture to which one minnow is as good as another and both useful only as food for bass, still a thorough survey in the hands of intelligent men, of the waters of any region cannot fail to throw much light on the habits and needs of the various food fishes, and we shall look with much interest for the final results of the work in Michigan.

The other work of the Fish Commission is in the direction of fish-hatching, the protection of the young of valuable kinds until they are able to take care of themselves. The value of this work is most great, now fortunately beyond question, and its methods are reaching a high degree of perfection.

I need only say that my deepest interest in science lies in the direction of the question of the distribution of organisms and in their adaptation to their surroundings and I should be glad if I were able to contribute even a little to making our knowledge of this subject practicably available in the direction of causing two big fish to grow where one little one grew before.

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THE COMMON FISH.

BY DR. J. C. PARKER.

It is very natural that the better varieties of fish should first receive the attention of fish culturists, but when the best method of conducting the hatching of these becomes settled, attention will be called to those commonly called "soft fish," such as the much abused "sucker," "bull-head," "perch," "rock bass," "croppie," "sturgeon," in fact, all of the native fish that furnish good and wholesome food to a large number of people throughout the state. The value of the common sucker as a food fish is but little understood or appreciated. In the early spring—at the spawning season—hundreds of thousands of these are caught in nearly all the waters of the state, furnishing many tons of very good food to the inhabitants. But the increased fishing for them in all manners of ways, from hook and line to spear and net, and at a time when to kill them is to kill the production for the year, together with the obstructions placed in the way of their reaching their spawning grounds by the numerous dams that span the rivers and creeks they frequent, is telling upon the production very rapidly, and unless some method of artificial culture shall be instituted they will become a thing of the past, with nothing better to take their place. Feeding as they do, upon the low forms of life that exist at the bottom of the waters they inhabit, they abstract nothing from the common weal, as do the more rapacious varieties met. In fact it is doubtful if some of these rapacious varieties, as the pike, perch, black bass, etc., could exist in any considerable numbers if it were not for the prolific nature of these commoner forms of fish life. Nature always strikes an even balance, and if any special variety of animal or vegetable life is obliterated or curtailed it has a corresponding effect upon some other form of life that depends upon the intercepted form for support or maintenance; and in too many cases these often controllable causes, through human agency, are neglected or overlooked until too late to remedy. At present this waste is not apparent in any varieties of fish that are propagated and planted by the fish-culturists, but it would seem to be the part of wisdom to pay some little attention to these side issues before they become the main ones. New forms of food are being constantly evolved from all food products, and noticeably so from the fish. For instance, the enormous industry that has been inaugurated in the canning of salmon, the production of the "American sardine" from the once worthless Menhaden are striking instances of the value of some forms of modern fish industries, and in our own state to-day one of the most valuable of commercial fish is the worthless sturgeon of a few years ago, and so assiduously is it sought for that the supply will become exhausted in a very short time unless the fish-culturist comes to the rescue. Some experiments looking towards a successful way in which their artificial propagation may be carried forward has been instituted with a fair prospect of success, and it is the desire of this commission to spend as much time and money upon this interesting variety as is possible without neglecting the more prominent work of the commission. The common bullhead is one of the best varieties of our common fish, and its value as a food fish has been greatly under-rated; living and thriving in all of our small inland lakes, and caught by the "small boy" with a pin hook, it has become a synonym for low stupidity, when in fact its protection and care of its young is one of the marvels of fish life, and there is hardly a doubt but that if the same intelligent cultivation could be carried on with this fish as there has been with the carp surprising results would be obtained.

Persons throughout the state are constantly calling on the commission to furnish them with fish for waters in their vicinity, when, in many instances, the waters already hold better fish for the localities than any the commission could furnish. One of the most important things for the general public to know is the value of neglected things right at their own doors.

The indiscriminate capture and destruction of every kind of fish at all seasons and in any manner is a constant and crying evil that can only be remedied when the general public can be brought to see that it is a subject that concerns every one, and more especially the poorer classes, who have not the money to purchase luxuries that are really in their hands already, or might easily be if the proper laws were made and enforced.

NO 11.—REPORT OF THE FISHERY COMMITTEE OF THE HOUSE OF REPRESENTATIVES IN THE SESSION OF 1887.

By unanimous consent, the committee on fisheries reported as follows:

The undersigned committee on fisheries beg leave to report that in accordance with custom they, during the vacation of the session in the month of February, visited the fish stations of the state located at Detroit, county of Wayne; Paris, county of Mecosta; and Petoskey, county of Emmet.

On February 7, 1887, your committee on fisheries met at the office of the State Board of Fish Commissioners, located at Detroit, and were shown the accounts of said board and the manner of the keeping of the same; also the method of gathering statistics regarding the interest of the state in fish and fisheries, together with all the facts regarding the labors of said commission in any way pertinent to the interest of the state. In this connection we would state that it is the object of the commission to propagate and cultivate fish for the purpose of planting in the inland lakes and streams; and in the bays, harbors and chain of great lakes of the state, so far as its jurisdiction extends, and to take such steps and use such action as will best promote and preserve the fish industry of the state, under the powers delegated to them by law.

In order that your honorable body may be made better acquainted with the details of this item of trade, your committee would state that the catch of the fishermen of Michigan amounted in the past year to nearly 26,400,000 pounds, yielding to the parties so engaged not less than $800,000, employing over seventeen hundred persons, sixty-six steam tugs, three hundred and eighteen sail boats, two hundred and thirty-two pound net boats, and one hundred and sixty-five skiffs.

The value of nets, boats, docks and buildings engaged in this traffic is estimated at $1,100,000.

We would also state that the territory of the fishing grounds within the jurisdiction of the state, in the great lakes, amounts to 30,000 square miles, or an area equal to three-fifths of the total land area of the State; that the coast line extending along the east and north shores of Lake Michigan, the south shore of Lake Superior, the north and west shores of Lake Huron, and the shores of Lakes St. Clair and Erie is over two thousand miles in length. The coast line so designated is totally exclusive of any of the inland waters of the state, and is given for the purpose of calling the attention of the members of the legislature to the facts in the case, and of enlisting their attention and support in behalf of this industry.

DETROIT STATION.

Visiting this station your committee found a commodious wooden building, in size forty by eighty feet, consisting of a main room and office, with storage room attached, devoted to the sole purpose of the propagation and hatching of whitefish.

Its capacity is 50,000,000 annually, and it was estimated at the time of our visit that 40,000,000 eggs were in process of hatching. Of this number it is believed that not more than ten per cent will fail to mature while in process of incubation.

Whitefish eggs hatch in the months of March and April, and as soon as the young fry are in readiness they are placed in cans provided for the purpose of transporting them, and forthwith distributed and planted in the various waters of the state, according to the orders received by the commissioner for them.

From this station of Detroit alone there were sent out for distribution and planted during the season of 1886, 36,420,000 whitefish. These were planted in the waters of Lakes Michigan, Huron, St. Clair, Traverse and Saginaw Bays, Detroit river and some of the inland lakes.

Mr. Eli Tinlan is the overseer of this station, and your committee report it complete in its appointments, and faithfully, competently and economically carried on.

PARIS STATION.

This fish hatchery is situated on the Grand Rapids & Indiana Railroad, in the county of Mecosta, and at present is used exclusively for the propagation of brook trout. It comprises 118 acres of land, traversed by two streams, named Cheney and Little Buckhorn creeks, respectively. It is equipped with a hatchery, and a superintendent's and overseer's house. These streams empty into the Muskegon river. Along Cheney creek several fish ponds have been formed in which many thousands of stock brook trout are kept for breeding purposes. The hatchery has a capacity of 1,500,000 brook trout per annum, and when visited by your committee 1,300,000 young trout were beginning to hatch out.

Mr. O. D. Marks is the overseer of this station, and everything connected therewith exhibited knowledge, care, and attention. From this station during the season of 1886, 719,000 brook trout were hatched and distributed for planting.

PETOSKEY STATION.

This station is used for the hatching of whitefish, and is situated on the line of the Grand Rapids & Indiana railroad, on the shores of Little Traverse Bay, in the county of Emmet. The capacity of this station is 33,000,000 whitefish per annum. It is well managed by Mr. A. W. Marks, as overseer; comprises a hatchery and residence, and in this season (of 1887) will plant about 25,000,000 whitefish.

GLENWOOD STATION.

This station, situate in Cass county, is used for the propagation of carp. Your committee have not as yet had time to visit it, and therefore have no report to make concerning it.

IMPROVEMENTS.

1. Your committee recommend the building of a platform and veranda extending across the front of the Detroit hatchery building, made necessary as a suitable approach and protective shade.

2. The building of a second hatchery house at Paris station, and making the different improvements suggested in the estimates of the board herewith attached, for the reason that the facilities of said station will readily admit of the propagation of 5,000,000 brook and other trout annually with very slight additional expense to that now incurred, together with the fact that the orders received from all parts of the state for trout fry for planting being far in excess of the supply, and in excess of the capacity of the present hatching building, warrants the committee in recommending more room and increased capacity.

In conclusion, your committee desire to say that whenever opportunity offered, they made inquiry into the results of fish planting, and we were assured by many practical, observing persons that in the great lakes, and in the inland lakes where whitefish have been planted, the most gratifying results are to be seen, and that in the many inland streams where brook trout have been planted they have thrived and grown in the most satisfactory manner.

We wish to say too, that the board of fish commissioners are gentlemen devoted to their work, who give a large share of their time, without pay, as good citizens to this work, and as a result of our investigations we would recommend that the appropriations asked for by them, of this legislature, may be granted.

E. Z. PERKINS,
Chairman.

PARIS STATION.—*Continued.*

1887. Feb. 19	39°
20	41
21-22	40
23	41
24-25	38
26	40
27	37
28	39
Mar. 1	38
2	40
3	39
4	38
5	36
6	39
7	41
8	39
9	42
10	40
11	42
12	41
13	40
14	36
15	37
16-20	38
21	40
22	38
23	37
24	39
25	37
1887. Mar. 26	36°
27	37
28	36
29-31	37
April 1	40
2	38
3	39
4-5	40
6	38
7	40
8-9	38
10	39
11-12	40
13	41
14-15	40
16	42
17-19	41
20	43
21	45
22	46
23	45
24	43
25	42
26	41
27	42
28	43
29-30	44
May 1	48
2	49

During trout hatching season from September 30, 1887, to May 31, 1888.

1887. Sept. 30	50°
Oct. 1-5	47
6-9	46
10-14	48
15-18	46
19-23	47
24-31	46
Nov. 1-4	47
5	46
6-9	44
10-16	43
17-25	44
26-30	43
Dec. 1-6	42
7-12	43
13-15	41
16-20	40
20-25	39
26-31	37
1888. Jan. 1-3	37
4-7	38
8-12	39
13-15	38
16	37
17-18	36
19	34
20	33
21	32
22	35
23	38
24	37
25-28	36
29-30	41
31	42
Feb. 1	43
2	41
3	43
4	42
1888. Feb. 5	40°
6	39
7	40
8	37
9	33
10	34
11	33
12	41
13-14	40
15	36
16-17	42
18	40
19	41
20	42
21	39
22	38
23	41
24-25	42
26	40
27-28	36
29	40
Mar. 1-2	40
3-4	38
5	37
6-8	36
9	40
10	42
11	40
12	38
13	36
14	37
15	40
16	42
17	38
18-19	42
20-21	38
22	36
23	35
24	36

PARIS STATION.—*Continued.*

1888. Feb. 25-28	40°
29-31	38
April 1	40
2-4	39
5-7	38
8-9	42
10	40
11-12	38
13-14	40
15-16	42
17	40
18	42
19	43
20-23	44
24	45
25-26	44
27	46
28	48
29	46
30	44
1888. May 1	44°
2-4	46
5-7	48
8	44
9-10	46
11	48
12	50
13-14	44
15-17	46
18	45
19	44
20-22	46
23	50
24	52
25-26	48
27	43
28	47
29	49
30-31	52

DETROIT STATION.

Temperature of water during the whitefish hatching season from Nov. 13, 1886, to April 15, 1887.

1886. Nov. 13-15	42°
16	41
17	42
18-19	41
20-22	40
23-24	41
25	40
26-27	39
28	38
29	37
30	36
Dec. 1-3	35
4	34
5-15	35
16-27	34
1886. Dec. 28-31	33°
1887. Jan. 1-31	33
Feb. 1-3	33
4-28	32
Mar. 1	32
2-31	33
Ap'l 1	33
2-3	34
4-7	35
8	37
9-10	39
11	40
12-13	41
14-15	42

During whitefish hatching season from Nov. 16, 1887, to April 18, 1888.

1887. Nov. 16-18	43°
19	42
20-21	41
22-27	39
28	38
29-30	37
Dec. 1-16	36
17-20	35
21-29	33
30	32
31	33
1888. Jan. 1	33
2-5	32
6	33
7	32
1888. Jan. 8	33°
9-12	32
13	33
14-31	33
Feb. 1-22	32
23-24	33
25-29	32
Mar. 1-8	32
9-11	33
12-30	32
Ap'l 1-3	34
4	36
5-7	38
8-17	39
18	40

PETOSKEY STATION.

Temperature of water during the whitefish hatching season, from Nov. 24, 1886, to April 4, 1887.

1886. Nov. 24-27	47°
28-30	46
Dec. 1-7	45
8-14	44
15-21	43
22-26	41
27-31	40
1887. Jan. 1-6	39
7-15	38
16-24	37
25-31	36
Feb. 1	36
1887. Feb. 2-8	37°
9-11	36
12-13	35
14-18	36
19	35
20	36
21-28	35
Mar. 1-6	36
7-15	35
16-22	36
23-31	37
April 1-4	38

PETOSKEY STATION.—*Continued.*

During whitefish hatching season from Nov. 20, 1887, to March 25, 1888.

1887.		1888.	
Nov. 20-25	48°	Jan. 9-18	37°
26-30	47	19-22	35
Dec. 1-8	44	23-31	34
9-16	42	Feb. 1-3	34
17-21	41		
22-28	40	4-8	35
29-31	39	9-29	34
1888.		Mar. 1-6	34
Jan. 1-8	39	7-25	35

The catch of fish for 1886 actually reported to the Fish Commission by 180 firms, employing 625 men, was as follows:

	Pounds.
Whitefish	2,652,325
Trout	1,122,986
Herring	1,173,912
Bass	15,695
Sturgeon	440,978
Pickerel	514,624
Blackfins	34,000
Other kinds	201,623
Total pounds	6,156,143
Caviare	62,924
Total value at wholesale cost	$214,806.99
Total value at market price	492,491.44

The following nets were in use:

	No.
Pound nets	335
Gill nets	7,502
Seines	17
Fykes	54

The following boats were used:

Steamers	24
Sail boats	104
Pound boats	118
Skiffs	14

The catch of fish for 1887 actually returned to the Fish Commission by 146 firms, employing 555 men, was as follows:

	Pounds.
Whitefish	2,756,419
Trout	1,517,816
Herring	998,985
Bass	3,931
Sturgeon	299,843
Pickerel	447,943
Other kinds	238,142
Total pounds	6,263,079
Caviare	39,202
Total value at wholesale cost	$215,526.16
Total value at market price	501,046.33

The following nets were in use:

	No.
Pound nets	360
Gill nets	6,419
Seines	37
Fykes	21

The following boats were used:

Steamers	19
Sail boats	78
Pound boats	122
Skiffs	40

INVENTORY.

PARIS STATION.

118 acres of land, with overseer's house and meander of Cheney creek		$3,000 00
Superintendent's house	$1,400 00	
Barn	315 00	
Ice house	28 00	
Shop and office	100 00	
Old hatchery	600 00	
New hatchery	4,000 00	
Car house	200 00	
	$6,643 00	
Ponds, races, and other improvements to ponds	3,300 00	
		9,943 00
		$12,943 00
Pump logs	$260 00	
Apparatus and tools	690 00	
Two camp outfits	175 00	
		1,125 00
Total		$14,068 00
Car for transporting fish		3,550 00

DETROIT STATION.

Buildings, with frames and tanks	$6,710 00
Chase automatic glass jars	1,276 30
Fish cans	875 00
Tools, apparatus and furniture	636 37
Fishery at Fort Wayne	100 00
Total	$9,597 67

PETOSKEY STATION.

Building, water pipes and fixtures	$3,513 00
Residence	750 00
Four-inch main water supply	514 00
Total	$4,777 00

GLENWOOD STATION.

Winter house	$150 00
Cans	75 00
Tools, apparatus and fixtures	25 00
Total	$250 00

SECRETARY'S OFFICE.

Furniture	$110 00
Books and stationery	40 00
Library	30 00
Total	$180 00

RECAPITULATION.

Paris station	$14,068 00
Detroit station	9,597 67
Petoskey station	4,777 00
Glenwood station	250 00
Car for transporting fish	3,550 00
Secretary's office	180 00
Total	$32,422 67

INSURANCE.

PARIS STATION.

New hatchery	$2,500 00
Old hatchery	300 00
Superintendent's residence	600 00
Superintendent's barn	100 00
Overseer's residence	400 00
Trays, etc., in new hatchery	350 00
Trays, etc., in old hatchery	200 00
Camp outfit, etc	300 00
Wagons, harness, etc., in Superintendent's barn	50 00
Office and shop	200 00
Contents of office and shop	100 00
Car house	125 00
Total	$5,225 00

DETROIT STATION.

House	$3,000 00
Automatic jars	1,125 00
Total	$4,125 00

PETOSKEY STATION.

Hatchery	$1,200 00
Dwelling	800 00
Total	$1,500 00

Wm. A. Butler, Jr., Treasurer of the State Fish Commission, in settlement with Board of State Auditors, for year ending Sept. 30, 1887.

	Current Account, Quarter Ending Dec. 31, 1886.		
1886. Oct. 1.	Cash on hand	$396 18	
	From State Treasurer	3,000 00	
	From other sources	630 27	
	Disbursements as per vouchers		$4,729 57
	Quarter Ending March 31, 1887.		
1887.	From State Treasurer	3,000 00	
	Disbursements as per vouchers		2,899 83
	Quarter Ending June 30, 1887.		
	From State Treasurer	3,000 00	
	Disbursements as per vouchers		2,375 75
	Quarter Ending Sept. 30, 1887.		
	From State Treasurer	4,178 98	
	Disbursements as per vouchers		3,326 82
	Balance on hand		873 46
		$14,205 43	$14,205 43
	Special Account, Quarter Ending Dec. 31, 1886.		
1886. Oct. 1.	Balance on hand	$2 72	
	Disbursements as per vouchers		$2 72
	Quarter Ending Sept. 30, 1887.		
1887. July.	From State Treasurer	5,535 00	
	Disbursements as per vouchers		4,922 87
	Balance on hand		612 13
		$5,537 72	$5,537 72
	Special Account, Deficiency for 1886.		
1887. July.	From State Treasurer	$350 00	
	Disbursement as per voucher		$350 00
		$350 00	350 00

OFFICE OF BOARD OF STATE AUDITORS,
Lansing, November 30, 1887.

I hereby certify that the Board of State Auditors this day examined the within account current of the receipts and disbursements of William A. Butler, Jr., Treasurer of the Board of Fish Commissioners of the State of Michigan, for the year ending September 30, 1887, and find the same to agree with his vouchers on file in the office of the Auditor General, and find the balances on hand at that date to agree with the books of the Auditor General and have settled with said Treasurer on that basis.

G. R. OSMUN,
Chairman of the Board of State Auditors.

Wm. A. Butler, Jr., of Detroit, Michigan, Treasurer of the State Fish Commission, in Settlement with Board of State Auditors for Year ending Sept. 30, 1888.

	Current Expenses to Dec. 31, 1887.		
1887. Oct. 1.	Balance on hand		$873 46
	Cash from State Treasury		4,178 69
	Cash from other sources		411 72
	Vouchers	$5,484 95	
Dec. 31.	Balance overdrawn		21 08
		$5,484 95	$5,484 95
	Current Expenses to March 31, 1888.		
1888. Jan. 1.	Overdrawn	$21 08	
	Cash from State Treasury		$4,178 83
	Cash from other sources		47 51
	Vouchers	3,621 28	
March 31	Balance	583 98	
		$4,226 34	$4,226 34
	Current Expenses to June 30, 1888.		
1888. April 1.	Balance on hand		$583 98
	From State Treasury		4,179 44
	From other sources		20 07
	Vouchers	$4,148 15	
June 30.	Balance	635 34	
		$4,783 49	$4,783 49
	Current Expenses to Sept. 30, 1888.		
1888. July 1.	Balance on hand		$635 34
	From State Treasury		4,178 98
	Vouchers	$4,932 45	
Sept. 30.	Balance overdrawn		118 13
		$4,932 45	$4,932 45
	Special Expenses to Dec. 31, 1887.		
1887. Oct. 1.	Balance on hand		$612 13
	Vouchers	$575 89	
Dec. 31.	Balance on hand	36 24	
		$612 13	$612 13
	Special Expenses from Jan. 1, 1888.		
1888. Jan. 1.	Balance on hand		$36 24
	Vouchers	$36 24	
		$36 24	$36 24

OFFICE OF BOARD OF STATE AUDITORS,
Lansing, Dec. 26, 1888.

I hereby certify that the Board of State Auditors this day examined the above account current of receipts and disbursements of William A. Butler, Jr., Treasurer of the State Fish Commission, for the fiscal year ending Sept. 30, 1888, and find the same to correspond with the books of the Auditor General, and find the balance on hand at that date to agree with the books of the Auditor General, and have settled with said Treasurer on that basis.

G. R. OSMUN,
Chairman of the Board of State Auditors.

INSTRUCTIONS TO CHARLES H. BOLLMAN WITH MICHIGAN FISH COMMISSION'S CREW EXAMINING INLAND LAKES, SEASON OF 1888.

WASHINGTON, D.C., *July 5, 1888.*

Charles H. Bollman, Esq., care John H. Bissell, Esq., President Michigan Fish Commission, 33 Moffat Block, Detroit, Michigan:

DEAR SIR: Your duties in connection with the Michigan field party will be mainly those of a naturalist, to collect and preserve specimens of fishes and other aquatic animals, and make observations upon their distribution, abundance, habits, usefulness, etc.

The main object of your work will be to obtain a thorough and comprehensive knowledge of the aquatic fauna of the region, looking toward economic results.

The fishes are of greatest importance, and should receive most attention. You will not be able to carry a very large stock of alcohol with you in the field, and must therefore exercise due judgment in the selection of specimens to be preserved; always taking in preference the rarer species or those requiring comparison with types for their proper identification. It will be best, however, to make as large a collection as your means will permit. A careful record should be kept of all species not preserved.

Complete lists should be made of all the fishes found in each lake or stream; and as full notes as possible on the abundance of each species, its special habitat, its habits so far as they can be observed, its spawning season, size, and uses in the region where collected, either for food, for bait, or for other purposes, its common name, food, life history, etc.

The food of the more useful species should be ascertained by an examination of the stomach contents. As you will probably not be able to make this examination in the field, the stomachs, properly opened to permit the entrance of alcohol, should be preserved separately, either in bottles or in cloth bags placed in jars. Always save the stomachs with the contents, in order that their number may be known.

Relative to the life history, the most that you can expect to do will be to keep a diligent outlook for the young and eggs of all species, preserving a sufficient quantity of each in alcohol. Evidence respecting the time of spawning may also sometimes be obtained by examining the ovaries.

If any of the useful species have decreased in abundance, obtain as much evidence as possible respecting the amount of decrease, and its extent and causes.

Note all introduced species; ascertain the time of their original planting, if possible; observe whether they have become acclimatized and breed naturally.

Carefully examine the exterior surface, the gills, mouths and stomachs of fishes for parasites, which should be carefully preserved.

Preserve all specimens (or a fair number) of crayfishes and other crustaceans, mollusks, worms and other aquatic invertebrates which you collect. In fact it is my desire to obtain as much information as possible respecting the aquatic invertebrate fauna of the region you are about to visit—the names of the species, their abundance, distribution, their value to man in any way, and their relative importance as food for fishes. The dredge which has been forwarded to Mr. Bissell will enable you to obtain material from the bottom of the lakes. Crayfishes are sometimes taken in the seines. Some species live under stones. Mollusks often inhabit the shallow water near the shore. The dip-net should be used among the aquatic plants; and where such plants are abundant and the water sheltered, small organisms, such as Entomostraca and insect larvæ, generally swarm in great numbers.

Preserve all the invertebrates from each special locality in a separate bottle or vial.

If you hve sufficient botanical knowledge record the commoner aquatic plants in each lake, their relative abundance, and their distribution. It will also be well to note the general character of the land vegetation of the region; especially the prevailing trees, and their proximity to the water.

The amount of time at your disposal will necessarily influence the scope and minuteness of your inquiry, and I shall simply expect you to do the best you can.

Label all specimens very fully and carefully; giving date, locality, and all other necessary information; and make such additional memoranda in your note book as the occasion requires. Each bottle or lot of specimens should have a separate label plainly written with lead pencil. By using one series of numbers for your labels and note book, cross references can readily be made. Keep your notes well written up, and do not trust too long to memory. Suitable paper for labels will be sent you.

Trusting that you will have a pleasant and successful season, I remain,

Very respectfully,

(Signed) M. McDONALD,
Commissioner.

MICHIGAN FISH COMMISSION.

INSTRUCTIONS TO EXAMINING CREW.

SEASON OF 1888.

DETROIT, July 6, '88.

The superintendent will direct the crew where to begin operations in Kalamazoo county. The aim will be to finish that county and then come east in Calhoun county at the point most convenient for reaching the lakes to be examined there. If Calhoun county is finished before the superintendent calls the crew to go north, Jackson county will be visited. If the latter county is reached, it will be best to work in the same systematic way as formerly, so that if the whole county cannot be covered it will be completely done as far as the crew can go. For instance, it will be best to take the four northwestern or southwestern townships, or to finish up a chain of lakes.

The examinations this season are to be made in coöperation with the United States Fish Commission. To that end Mr. Charles H. Bollman will accompany the crew as the representative of the U. S. Fish Commission and as naturalist of the party. The officer in charge will see that Mr. Bollman is comfortably provided for at the camp, that his baggage is cared for and disposed of at his convenience, and that every facility is afforded him for the prosecution of his special work connected with the examinations. As a large part of the results of Mr. Bollman's work is for the benefit of this commission, we are interested in having it as complete and satisfactory as possible. Some of the ways in which assistance should be rendered him are as follows:

Whenever necessary see that he is provided with a boat, with one man to row if he requests it; to take his direction as to times and ways of using drag; to report to him every new form of life observed in or on the waters; to procure for him, if possible, any species of fish or duplicates he may need; under his direction to procure and furnish to him the stomachs of fish caught in the nets or by other apparatus.

Mr. Bollman will be expected to assist the crew in making up their regular report by identifying species if they are in doubt, by identifying varieties of food found in the stomachs of fish, and in making any observations on the characteristics of the waters or their fauna pertinent to the reports. It is hoped that as there is opportunity he may instruct the crew in matters connected with the examinations, and that he will make any suggestion that may tend to simplify, expedite or improve the work of the examining crew, or the result sought through their work.

So far as possible, the crew will examine the Kalamazoo river and spring brooks flowing it, looking for springs and spring-holes as indicating suitable water and places for brook-trout. The same for any large streams that can be reached from camp.

Get from all sources of information reports of brook-trout planted by the commission, taking names and addresses of informants, names and locations of streams referred to, and making notes of all points. In looking over streams inquire specially for indications of kinds and quantities of food.

JOHN H. BISSELL,
President.

LETTERS FROM FISHERMEN REGARDING WHITEFISH PLANTS.

FRANKFORT, MICH., *Aug. 15, 1888.*

Geo. D. Mussey, Secretary, Detroit :

In reply to yours of the 15th I will say, yes. I think the catch has increased, and planting is the only thing that will preserve the fishing interest of the great lakes.

Yours respectfully,

CHAS. BURMEISTER.

ALCONA, MICH., *Sept. 17, 1888.*

Geo. Mussey, Secretary, Detroit :

DEAR SIR:—In regard to the fish planting, I think it is doing a great deal of good. It is increasing the fish in the lakes. I have fished on grounds where fish have been planted and have caught them. I can tell you more after the fall fishing is over.

Yours respectfully,

JACKSON GREENMAN.

PENTWATER, MICH., *Aug. 22, 1888.*

Mich. Fish Commission, Detroit :

Speaking of whitefish, I would say they have been strangers around here for three years. I have seen some small ones this summer where we were fishing; I should think they would weigh from one-quarter to one-half pound. I think in planting, the fish should be put in the big lakes instead of the small ones, because the planted fish would have a better chance to get away from the perch and other small fish that eat them.

Yours,

ROBERT VERM.

No whitefish have been planted in small lakes for several years past.

COMMISSIONERS.

ST. JAMES, MICH., *Aug. 22, 1888.*

Geo. D. Mussey, Secretary:

DEAR SIR:—I received yours of the 15th inst. In regard to the fishing this year I would say the summer fishing is over, and has been very good with pound nets. The small mesh twine is done away with, and this gives the small fish a chance to get big. I have seen a class of whitefish that I never saw before. The ends of their fins are a little dark. I believe they are fish planted by your commission, and that the fishing will be better again.

Yours respectfully,

FRED BUTTS.

DETROIT, *August 22, 1888.*

Geo. D. Mussey, Esq., Secretary, City :

DEAR SIR:—Your circular of 15th inst., asking for information as to the success of planted whitefish, is at hand, and in reply would say that in the increased catch of the same, especially in Lake Erie, this present year, and the size of fish (being not of full size), there is no reasonable doubt of their being planted fish. The increased catch in Detroit river last November also carries out the same theory, as they were much smaller and more soft and tender than the usual Detroit river whitefish. All of the fishermen and fish dealers with whom I have discussed this matter claim they are planted fish.

With suitable laws, properly enforced, to keep our lakes and rivers free from the refuse of sawmills, I believe it practicable to stock our waters again with the delicious whitefish.

Wishing you success, I am

Very respectfully yours,

JAS. CRAIG.

ISLAND HOUSE, TRAVERSE BAY, MICH.

Geo. D. Mussey, Secretary:

SIR :—In answer to your printed questions of August 15, I will say that I have fished right here, seven miles north of Traverse City, for the last eleven years. Of course there are not so many fish here now as there used to be; that is, not so many for me. I am a gill-net fisherman and always fish in deep water. Eleven years ago, so far as I know, there was not more than half a dozen pound nets in the bay, but five years ago the pound netters began to flock in here and have come more and more every year, and this fall there will probably not be far less than a hundred pound nets in the bay. You of course know they cover all the shoals and spawning grounds between this and the mouth or north end of the bay. I am now getting about half whitefish and half trout, but in a month from now, when the pound nets are all in, a whitefish will be a rare thing here. The law makes these pound nets 3½ inch mesh as manufactured; when seamed and tarred they are less than three inches and will hold very small fish. Now, inasmuch as you have asked me for my opinion of whitefish planting, I must say that in my opinion, if pound nets are not prevented from sweeping whole schools of spawning whitefish off their shoal spawning grounds, the amount of fish can never be kept up by planting or in any other way, for they will be swept clean every year. So far the law has been against gill nets and in favor of pound nets, for, so far as I know, a gill netter dare not set his nets on shoal spawning grounds, for if he does the chances are his nets will be chafed out and lost. Last fall I got more fish than any other fall since I have been here, but they were all black fins or long jaws and trout. After the pound nets got in I got no whitefish. I remember one morning I lifted 375 pounds and there was only nine pounds of whitefish among them. There are a great many more tons of whitefish caught in the bay now than there used to be, but the fish are small and get smaller every year here. It is my opinion the whitefish I get are planted fish, but those who planted them failed to put any ear marks on them, so I cannot tell for sure. In fact I don't see how they can help being planted fish, for it seems impossible for any fish to spawn on any spawning grounds in this bay without being caught in a pound net first.

I have a remedy for all this, but it is not likely I will ever be a law-maker, and we will continue to have our fish laws dealt out to us by men who are not practical fishermen and know less than nothing about the fishing business. I say plant fish, by all means plant fish; plant as hard as you can with both hands. It is a good thing, but for God's sake give them five or ten minutes some time during the fall to spawn. I say stop everybody from fishing in twenty-five feet or less of water for ten or twenty days in spawning season and we will soon have whitefish again--plenty of them.

I think there has been salmon planted here. I caught one last summer that weighed six pounds.

Yours,

R. S. Bassett.

St. James, Mich., *August 23, 1888.*

Geo. D. Mussey, Sec'y Michigan Fish Commission:

Sir:—I believe good results have followed the planting of whitefish. My own experience this season convinces me that the catch of whitefish has increased. We caught a different run of whitefish this season and believe them to be planted fish. We had a good catch.

Wm. J. Gallagher.

Holland, Mich., *August 27, 1888.*

Geo. D. Mussey, Sec'y:

Dear Sir:—I have caught more whitefish this season than last. I have caught a large quantity which I am sure were fish planted by the commission. I will try and give you more information next season.

Yours respectfully,

Gus Baker.

Frankfort, Mich., *August 23, 1888.*

Michigan Fish Commission:

In reply to yours of the 18th, I would say I will give, with pleasure, all the information I can in regard to the planting of fish. I have watched very carefully ever since the State undertook to propagate fish artificially, and am very glad to say that so far as my knowledge goes I have seen plenty of fish which had been planted by the State. I will give a few facts that have come to my knowledge during twelve years of my experience as a fisherman. In spawning time, as all know, the whitefish deposit their eggs on honeycomb rocks and generally very close to shore. I have known these to be deposited as close as in four feet of water. All these places swarm with perch and crawfish (crabs), which feed continually on these eggs from the time they are deposited until spring. What are not devoured are washed ashore in storms, and I have seen the beach covered with whitefish and trout spawn. Winter sets in and in these shallow places the water is frozen to the bottom and the eggs killed or carried away. In my opinion but one per cent or less are hatched.

My reasons for believing that artificial propagation is a success are these: First, there are places along the shore, away from spawning beds, where in years gone by no whitefish were caught with pound-nets, but where whitefish are now taken; second, of the fish caught not more than 10 per cent. contain spawn, which shows that they are young fish; third, of all the fish caught in pound-nets in the proximity of the spawning beds about 40 per cent. contain spawn, showing that many now reach full growth; fourth, in all localities a mile or more from shore a great many full-grown fish are caught, about 93 per cent. of which contain spawn, which shows that all the fish leave the shore as soon as they attain full growth, and do not swim along the shore after that.

Yours,

Thomas Riedeck.

Geo. D. Mussey, Secretary: Alcona, Mich., *August 25, 1888.*

Dear Sir:—In regard to fishing, I would say that I have not fished for whitefish since 1886. That fall I caught eight or ten young whitefish that would weigh about one pound. I let them go in the lake again. I have fished since I was a small boy and never saw a young whitefish until they commenced planting them in the lake. I think it will be a big thing in the course of time.

Respectfully yours,

Sam. Hill.

Geo. D. Mussey, Secretary: Forester, Mich., *September 5, 1888.*

Dear Sir:—In reply to your letter of August 15, will say we are confident that the planting of whitefish is a success.

We notice more small fish than usual the present season. We got a good many fish that would average about 2½ pounds. In our opinion, these are some of the first planting.

Yours very respectfully,

Allue Bros.

Geo. D. Mussey, Secretary: Cheboygan, Mich., *August 28, 1888.*

Dear Sir:—Yours of 15th received, in which you ask about whitefish. The catch has increased during the last two seasons in this vicinity, but I cannot say whether or not fish have been caught which were planted by the commission.

Yours truly,

Andrew Trombley.

Mackinaw City, Mich., *September 3, 1888.*

Geo. D. Mussey, Esq., Sec'y Mich. Fish Com., Detroit:

In reply to yours of Aug. 15 would say the present season has been a much better one than usual. The catch of whitefish has been more than double that of any year since 1880, and I am satisfied that it is caused by the planting of whitefish by the commission, which I believe is the only way to keep the supply good. Thanking you for your inquiries and your work, I am

Yours truly,

Alex. Duffina.

ST. JAMES, MICH., *September 17, 1888.*

Geo. D. Mussey, Secretary Michigan Fish Commission :

SIR:—I have caught a large run of whitefish this season, and I do think they are some of the whitefish that were planted by the fish commission. I have good reasons to believe that it benefits the fishermen to plant fish.

Yours respectfully,

JAMES MOONEY.

Upon the receipt of the above letter, Mr. Mooney was written and asked to give some of the reasons for believing that the fish caught by him were planted. In reply the following letter was received:

ST. JAMES, *October 11, 1888.*

Michigan Fish Commission, Detroit:

Yours of September 20 is at hand. You make inquiries as to how I know that it benefits fishermen. Because one-third of the whitefish we caught this summer were Lake Erie fish; therefore I know they came from fry planted, as the Lake Erie fish are a stout, wide, small species of whitefish, with the tops of fins and tail black, while our natural Lake Michigan whitefish are long and slim, with one color of fins and tail. We never saw the Lake Erie fish here until we caught a few last season and great numbers this season in gill nets as well as whitefish nets.

Yours,

JAMES MOONEY.

In explanation of above reference to Lake Erie whitefish, it may be said that nearly all spawn taken by the commission since the beginning of artificial propagation has been taken from Lake Erie or Detroit river fish.

LETTERS FROM CITIZENS REGARDING BROOK TROUT PLANTS.

MT. PLEASANT, *August 13, 1888.*

Geo. D. Mussey, Sec'y:

DEAR SIR:—Your circular at hand and in reply would say that Mr. Geo. Granger has been at the head and front of trout planting in this county, and reports everything in first-class condition and every planting successful. The fishing is good and many avail themselves of the opportunity to engage in the sport of securing a most delicious fish for their tables. As near as I can ascertain the earliest planting was seven years ago in the town of Holland. This spring a brook trout weighing 3¼ pounds was caught, so Mr. Granger tells me. The fish have multiplied very rapidly, and it is expected that an abundance of the gamy little fellows will supply the tables of our people in a very few years. We appreciate the good the fish commission of the State has done for us.

Yours,

A. S. CONTANT.

PAW PAW, MICH., *Aug. 13, 1888.*

Geo. D. Mussey, Esq., Secretary Mich. Fish Commission:

DEAR SIR:—Your circular of the 16th ult. at hand. In reply would say that the results that have followed the planting of brook trout in the streams of this locality have proven fairly satisfactory, and that the streams so planted bid fair to furnish a good supply of that choicest of all fish.

Our citizens are highly pleased with the work that has already been done. There is still an opportunity for still further profitable work in the same direction.

Yours, etc.,

O. W. ROWLAND,

Ed. True Northerner.

NEWAYGO, MICH., *Aug. 16, 1888.*

Geo. D. Mussey, Secretary, Detroit:

The results of planting brook trout in this vicinity have been highly satisfactory. They grow rapidly, some very fine ones being taken every season. Our people are greatly pleased with the system, and without an exception that I know of, are deeply interested in it.

Respectfully,

E. O. SHAW.

GALESBURG, *Sept. 10, 1888.*

Geo. D. Mussey, Secretary Michigan Fish Commission:

DEAR SIR:—Your letter of inquiry in relation to the planting of brook trout in the streams in this locality is of special interest to me as well as to my readers. In reply: 1. The results have been very gratifying, so much so, that trout fishing in season is now considered the rarest sport by all piscatorial artists. Two beautiful specimens have been caught in Camel's Creek, near here, 12 inches long, and worthy of the editorial notices they received throughout the country. 2. Our citizens universally commend it, and only regret that all available streams are not more fully stocked.

Respectfully yours,

E. E. THRESHER.

EVART, MICH., *September 11, 1888.*

Geo. D. Mussey, Esq., Detroit, Mich.:

DEAR SIR:—Yours of the 10th inst. at hand and contents noted. In reply would say that there is brook trout in every creek on northwest side of Muskegon river from Hersey to the Big Clam river. You will see by map that there is a number of smal streams that are not named, and there is trout in every one of them and have been caught. It seems that they run up and down Muskegon river and have for three years. This is the way that we account for them being in all the small streams. On the southeast side of Muskegon river they are very scarce. In some of the creeks they run up in the spring, but the water is not adapted for them, and as soon as it gets warm they leave and run out into the Muskegon river again. Some of the largest trout that have been caught here were caught in the Muskegon river. In your letter you have a Bull creek and a Kill creek. There is only one; it should be Bull Kill creek. This is on southeast side between Evart and Hersey. There are a few in that, but nothing compared with the streams on other side of Big river. Twin creek is the best fishing of any. If there is any further information that I can assist you in will only be too pleased to do so.

Respectfully yours,

J. C. CREITH.

LANSING, *September 14, 1888.*

Geo. D. Mussey, Secretary Michigan Fish Commission:

SIR:—In reply to your circular, I would say the work of the State Fish Commission of planting brook trout in Berrien county has been decidedly successful, as I know from personal observation. I have had good fishing and have taken many good-sized trout in streams stocked by the state, and know that your efforts in this direction meet with general approval among our people, especially as we find by experience that the reputation that there is good trout fishing in our vicinity attracts a class of visitors and summer tourists who spend money freely among us and add not a little to our business prosperity.

Yours truly,

J. H. HATCH, *of St. Joseph.*

SHARON, *October 29, 1888.*

W. D. Marks:

DEAR SIR:—I write to tell you that we had 5,000 brook trout put in our brook a year ago last March and 4,000 last March. We have caught some of them nine and one-half inches in length and weighing four ounces. There are smaller ones, of course, and there may be larger.

Yours respectfully,

F. J. WILLIAMS.

ALPENA, *October 7, 1888.*

Geo. D. Mussey, Esq.:

DEAR SIR:—The 10,000 brook trout fry sent me have done splendidly. I caught seven this fall and put them back in the creek, except one, which weighed three-quarters of a pound and was thirteen inches long. The creek is full of young ones two and one-half to three inches long.

Yours,

HENRY BOTTORE.

BIG RAPIDS, *October 31, 1888.*

Geo. D. Mussey:

DEAR SIR:—Your circular was referred to me. I can say that every stream in this county is now filled with brook trout, and the scheme of planting them in the streams is generally regarded as a grand success.

Very respectfully,

W. F. SLAWSON,
City Editor Pioneer.

NOTICES FROM PAPERS IN REGARD TO BROOK TROUT PLANTS.

The Shelby *Independent*, of Oceana Co., of September 14, 1888, says:

"The history of the speckled trout in the brooks of this county is that may prove interesting to our readers at this time. The Oceana County Sportsmen's Society was organized in 1878, and 30,000 young trout planted in the streams of the county in February of that year. Two years later the plant was examined by the State Fish Commissioner, and pronounced a complete success. About 75,000 young trout were planted that spring. Since then there have been very few planted until the spring of the present year, when perhaps 20,000 to 25,000 were planted.

"Thus it will be seen that about 130,000 trout have been planted here, and they were
protected by law in all seasons until May 1, 1884, since which time it has been lawful
to catch them with hook and line in the months of May, June, July and August of each
year. And the strings of speckled beauties that have been taken from the running
waters of our county since then are numerous and fine. One specimen caught the
present season weighed five pounds and one ounce, and dozens have been brought to
this place weighing from three to four and three-quarter pounds each. Sportsmen
from all over the state have visited our fishing grounds during the season just closed,
and gone away convinced that there was something more substantial than talk about
the fish stories of our citizens. Those who were most influential in securing the plant,
placing young fish in the waters, watching their growth and protecting them from
marauders while young, are, so far as we can recall their names, the following gentle-
men: E. J. Shirts, Shelby; E. D. Richmond, A. S. White and L. G. Rutherford, Hart;
D. C. Wickham, (George) and W. A. Rounds, Pentwater, and every one of these
chaps knows how to fish for and catch the handsomest, most speckled trout that
swim."

The Battle Creek *Moon* of August 3, 1888, says:

"Some years ago a fish commissioner was appointed for the purpose of stocking the
streams of the state with choice varieties of fish. As long ago as 1881, trout were
planted in brooks in this vicinity, and their growth has been a matter of watchful care
on the part of the Sportsmen's Club, of this city. This morning, in speaking of the
trout fishing in this locality with one of the club, we were told that they were thriving
beyond the most sanguine expectations of the members. He related the fact that
several large trout, weighing in the neighborhood of two pounds and a half, had been
taken, and they were supposed to belong to the first plant made in this locality. The
catch of one-half and pound trout has been large this season, no less than 300 having
been known to be taken from the Pratt brook alone, while the catch in the Austin
brook could not be estimated, as it appeared to be the fishing grounds of many of our
local fishermen, on account of its nearness to the city.

"He said that nearly all the streams that presented the requisite condition for the
growth of trout had been planted and that they all appeared to be thriving, and shortly
the locality would be famous for its trout fishing. The State Fish Commission have been
generous in their supply of small fry, every year large invoices being sent here, which
were judiciously and carefully distributed and planted by the Sportsmen's Club, and
before long the result would be noticeable. Our citizens generally appear to enjoy the
sport which these gamy little beauties afford, and their appreciation of the endeavors
of the commission is noticed in the conscientious manner in which they treat the plant,
always throwing back those that were too small for the pan with as little injury to
them as possible. On the whole, it is generally conceded that the labors of the com-
mission in this locality have been a grand success, the details of which have been
written up by competent members of the Sportsmen's Club and printed in the annual
report of the commission. Battle Creek can now boast of as good fishing as many of
the resorts, and people do not have to go miles away to enjoy a day with the rod and
lines, thanks to the State Fish Commission.

The Whitehall *Forum* of August 16, 1888, says:

"We believe every sportsman, both local and transient, who has visited the brooks
in this vicinity during the trout season this year has been amply repaid for his pains.
The fish have attained a good growth and the brooks are prolific of them. Several
trout weighing as high as three pounds have been killed here, and those weighing from
a pound and a half to two pounds have been ordinary. The flesh is firm and savory
and the brooks which thread the woods hereabouts appear to be perfectly adapted to
the thrift of the speckled beauties."

The Ypsilantian of August 30, 1888, says:

"Mr. Walter Pack, who probably knows as much of the subject as any one here,
assures us that the experiment in the streams south and west of this city has been very
successful, and that those streams are well stocked with trout, but are not yet open
because of successive plantings.

"A three pound trout, however, has been taken, showing the stream well adapted to
the development of this dainty and fastidious species."

The West Branch *Times* of August 17, 1888, says:

"At least twenty spring brooks in this county have been planted with brook trout from the State hatchery during the past ten years. The experiment has proven very successful and the growth and increase of the fish has been most gratifying. Only a few of the streams nearest town can yet be fished, many of those farther away having been planted within the past two years. But trout fishing is now an attractive amusement for our lovers of sport, and in a few years Ogemaw county will be celebrated as a resort for seekers after these most delicious of the finny tribe."

The Jackson *Patriot* of August 22, 1888, says:

TROUT FISHING.

WHAT THE WATERS OF JACKSON COUNTY WILL SUPPLY IN THIS DIRECTION WITHIN A FEW YEARS.

"Upon inquiring yesterday of C. B. Bush, Levi French and others who assisted in planting the fry it was learned that quite a number of good sized trout have been captured in Crouch's creek, some weighing a pound and a half.

"Those conversed with on the subject appear to be very confident of the success of the undertaking, and believe that within a few years the waters of this vicinity will permit as good trout fishing as any in the State."

LIST OF FISH COMMISSIONERS.

THE UNITED STATES:
- Col. Marshall McDonald, Commissioner, Washington, D. C.
- Capt. J. W. Collins, Assistant in charge of Fisheries Division.
- Richard Rathbun, Assistant in charge of Scientific Inquiry.
- Col. John Gay, Inspector of Stations.

Alabama:
- Col. D. R. Hundley, Madison.
- Hon. Chas. S. G. Doster, Prattville.

Arizona:
- J. J. Gosper, Prescott.
- Richard Rule, Tombstone.
- J. H. Taggart, Business Manager, Yuma.

Arkansas:
- H. H. Rottaken, President, Little Rock.
- W. B. Worthen, Secretary, Little Rock.
- J. W. Calloway, Little Rock.
- (This state has never made an appropriation for fish culture.)

DOMINION OF CANADA:
- Hon. John Tilton, Deputy Minister of Fisheries, Ottawa.
- (Inspectors of Fisheries for the Dominion of Canada, 1888: W. H. Rogers, Amherst, N. S.; A. C. Bertram, North Sydney, C. B. N. S.; W. H. Venning, St. John, N. B.; Wm. Wakeham, Gaspé Basin, P. Q.; J. H. Duvar, Alberton, P. E. I.; Thomas Mowat, New Westminster, B. C.; Alex McQueen, Winnipeg, Man.)
- (Officers in charge of the Fish Breeding Establishments: S. Wilmot, Superintendent of Fishculture, Newcastle, Ont.; Chas. Wilmot, officer in charge, Newcastle hatchery, Ont.; Wm. Parker, Sandwich, Ont.; L. N. Cattellier, Tadoussac, Q.; Philip Vibert, Gaspé, Q.; A. H. Moore, Magog, Q.; Alex Mowat, Ristigouche, Matapedia, P. Q.; A. B. Wilmot, Bedford, N. S.; C. A. Farquharson, Sydney, N. S.; Isaac Sheasgreen, Miramichi, N. B.; Charles McCluskey, St. John River, Grand Falls, N. B.; Henry Clark, Dunk River, P. E. I.; Thos. Mowat, B. C. hatchery, New Westminster, B. C.)

California:
- Joseph Routier, Sacramento.
- J. D. Harvey, Los Angeles.
- (Commissioner T. J. Sherwood resigned March 15, 1888.)

Colorado:
- G. F. Whitehead, Denver.

Connecticut:
- Dr. Wm. M. Hudson, Hartford.
- Robert G. Pike, Middleton.
- James A. Bill, Lyme.
- (This state has no official superintendent, most of the hatching being done by Henry J. Fenton, Poquonnock.)

Delaware:
- Charles Schubert, Odessa.

Georgia:
- J. H. Henderson, Atlanta.
- (Superintendent, Dr. H. H. Cary, La Grange.)

Illinois:
- N. K. Fairbank, President, Chicago.
- S. P. Bartlett, Quincy.
- Geo. Breuning, Centralia.

Indiana:
- Enos B. Reed, Indianapolis.

Iowa:
- E. D. Carlton, Spirit Lake.
- (Superintendent, Ole Bjorenson.)

Kansas:
- S. Fee, Wamego.

Kentucky:
- Wm. Griffith, President, Louisville.
- P. H. Darby, Princeton.
- John B. Walker, Madisonville.
- Hon. C. J. Walton, Munfordville.
- Hon. John A. Steele, Midway.
- W. C. Price, Danville.
- Hon. J. M. Chambers, Independence.
- A. H. Goble, Catlettsburg.
- J. H. Mallory, Bowling Green.

Maine:
- E. M. Stillwell, Bangor.
- Henry O. Stanley, Dixfield.
- B. W. Counce, Thomaston, Sea and Shore Fisheries.

*Maryland:
- Dr. E. W. Humphries, Salisbury.
- G. W. Delawder, Oakland.

Massachusetts:
- E. A. Brackett, Winchester.
- F. W. Putnam, Cambridge.
- E. H. Lathrop, Springfield.

Michigan:
- John H. Bissell, Detroit.
- Herschel Whitaker, Detroit.
- Joel C. Parker, M. D., Grand Rapids.
- (Superintendent, Walter D. Marks, Paris.)
- (Secretary, Geo. D. Mussey, Detroit.)
- (Treasurer, Wm. A. Butler, Jr., Detroit.)

Minnesota:
- William Bird, Fairmount.
- Niles Carpenter, Rushford.
- Robt. Ormsby Sweeny, St. Paul.
- (Superintendent, S. S. Watkins, Willow Brook, St. Paul.)

Missouri:
- H. M. Garlichs, Chairman, St. Joseph.
- J. L. Smith, Jefferson City.
- H. C. West, St. Louis.
- A. P. Campbell, Secretary, St. Joseph.
- (Superintendents: Philip Kopplin, Jr., St. Louis; Elias Cottrill, St. Joseph.)

Nebraska:
Willim L. May, Fremont.
R. R. Livingston, Plattsmouth.
B. E. B. Kennedy, Omaha.
(Superintendent, M. E. O'Brien, South Bend.)
*Nevada:
W. M. Cary, Carson City.
New Hampshire:
George W. Riddle, Manchester.
Elliott B. Hodge, Plymouth.
John H. Kimball, Marlborough.
(Superintendent of Plymouth and Sunapee hatcheries, Com. E. B. Hodge.)
New Jersey:
William Wright, Newark.
Frank M. Ward, Newton.
J. R. Elkinton, Pennsgrove.
New York;
E. G. Blackford, President, New York.
Gen. R. U. Sherman, New Hartford.
Wm. H. Bowman, Rochester.
A. S. Joline, Tottenville.
Henry Burden, Troy.
(Secretary, E. P. Doyle, room 311, Potter Building, New York city.)
(Superintendents: Fred Mather, Cold Spring Harbor; Monroe A. Green, Caledonia, James H. Marks, Bloomingdale; E. L. Marks, Fulton Chain, and E. F. Boehm, Mill Creek.)
(Shellfish Commission: E. G. Blackford, Commissioner; William G. Ford, Engineer; J. W. Merserau, Oyster Protector, 80 Fulton Market, New York.)
North Carolina:
Wm. J. Griffin, Chairman, Elizabeth City.
J. B. Watson, Englehard.
Wm. T. Caho, Bayboro.
Ohio:
C. V. Osborn, President, Dayton.
A. C. Williams, Secretary, Chagrin Falls.
J. C. Hofer, Bellaire.
John H. Law, Cincinnati.
Hon. Emory D. Potter, Toledo.
(Superintendent, Henry Douglass, Sandusky.)
(Chief Warden, L. K. Buntain, Dayton.)
Oregon:
F. C. Reed, President, Clackamas.
E. P. Thompson, Portland.
R. E. Campbell, Renier.
(Terms expire in February, 1889.)
Pennsylvania:
Henry C. Ford, President, 524 Walnut street, Philadelphia.
James V. Long, Corresponding Secretary, 75 Fifth avenue, Pittsburgh.
H. C. Demuth, Secretary of Board, Lancaster.
S. B. Stillwell, Scranton.
A. S. Dickson, Meadville.
Treasurer, W. L. Powell, Harrisburg.
(Superintendents: John P. Creveling, Allentown; William Buller, Corry.)
Rhode Island:
John H. Barden, President, Rockland.
Henry T. Root, Treasurer, Providence.
Wm. P. Morton, Secretary, Johnston.
South Carolina:
Hon. A. P. Butler, Columbia.
*Tennessee:
W. W. McDowell, Memphis.
H. H. Sneed, Chattanooga.
Edward D. Hicks, Nashville.
Utah:
A. Milton Musser, Salt Lake City.

Vermont:
Herbert Brainard, St. Albans.
F. H. Atherton, Waterbury.
Virginia:
Dr. J. T. Wilkins, Bridgetown.
West Virginia:
C. S. White, President, Romney.
F. J. Baxter, Treasurer, Sutton.
James H. Miller, Secretary, Hinton.
Wisconsin:
The Governor, *ex-officio*.
Philo Dunning, President, Madison.
C. L. Valentine, Secretary and Treasurer, Janesville.
Mark Douglas, Melrose.
A. V. H. Carpenter, Milwaukee.
Calvert Spensley, Mineral Point.
E. S. Miner, Sturgeon Bay.
(Superintendent, Jas. Nevin, Madison.)
Wyoming Territory:
Louis Miller, Laramie.