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DEPARTMENT OF COMMERCE AND LABOR
BUREAU OF FISHERIES

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GEORGE M. BOWERS, Commissioner

THE
GERMAN CARP IN THE UNITED STATES

BY

LEON J. COLE

APPENDIX TO THE REPORT OF THE COMMISSIONER
OF FISHERIES TO THE SECRETARY OF COMMERCE
AND LABOR FOR THE YEAR ENDING JUNE 30, 1904

Pages 523 to 641, Plates I to III

WASHINGTON
GOVERNMENT PRINTING OFFICE

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THE GERMAN CARP.

THE GERMAN CARP IN THE UNITED STATES.

By LEON J. COLE.

INTRODUCTION.

For a number of years there appears to have been in many sections of this country an increasing popular prejudice against the German carp. These fish were distributed very generally throughout the United States something over twenty years ago, with the idea that they would be extensively raised in ponds and so provide a supplementary income from small inland waters which were unsuitable for other fishes, or from land upon which artificial ponds could be constructed. It was inevitable that many of the fish should escape into the natural waters of the country; and within a few years many of our rivers and lakes were teeming with carp, for which, at that time, there was little or no market. With persons who had been able to obtain in abundance many species of our finer native fishes, the coarser flesh of the carp found little favor, and, under the circumstances, it was perhaps but natural that prejudice should arise, especially because the carp was supposed to be injuring the existing fisheries. In some cases the adverse opinions were founded upon facts and a knowledge of the habits of the fish; more often they were the repeated hearsay born of suppositions and complete ignorance of the subject or of misinterpreted observations. The newspapers also took the matter up, and the carp was decried on all sides without stint.

In the summer of 1901, in order to obtain evidence upon the matter, the writer was appointed by the United States Bureau of Fisheries (then the United States Commission of Fish and Fisheries) to make an investigation of the habits of the carp and to gather any available information relative to its usefulness or obnoxiousness. The work was done in connection with the general biological investigation of the Great Lakes under the general direction of Prof. Jacob Reighard, of the University of Michigan. Professor Reighard was not in active charge of the work, however, in 1901, Prof. H. S. Jennings, then also at the University of Michigan, acting as director during that season. I take pleasure in thanking both Professor Reighard and Professor Jennings for their interest in the investigation and for their readiness at all times to do everything in their power to further the work.

Probably the two regions in the United States where carp are found most abundantly are about the western end of Lake Erie and in the Illinois River and its tributaries. This investigation was begun, however, at Lake St. Clair, this locality being chosen because of such complaints as the following, which appeared in a Port Huron paper:

FISH IN LAKE ST. CLAIR—THE CARP ARE RAPIDLY DESTROYING ALL THE OTHER KINDS.

G—— B——, an old fisherman, who has plied his trade on Lake St. Clair three miles above Mount Clemens for twenty-three years, says in three years more there will be no fish except carp left in the lake. The carp eats the spawn and destroys the perch, bass and other good fish in those waters, and the supply is already much reduced. Mr. B—— suggests that the government offer a bounty of 3 cents or so for the destruction of the carp in order to save the other fish.

This particular paragraph is quoted because it gave the starting point for the field work, and because it illustrates so well the general tone of complaint against the carp. The shallow bays of the delta occupying the upper fourth of Lake St. Clair afford an excellent place for carp—except that possibly the water averages a little cold for their most prolific development—and they are to be found there in considerable numbers. Furthermore, the usual comparative clearness of the water makes it easier at times to observe the fish than in the muddier waters in which they are usually found. When the carp are rooting about in the bottom for food, however, even clear water is made so roily that there is little chance to watch them.

After about three weeks at the St. Clair Flats, the remainder of the summer, until August 31, was spent on Lake Erie, especially at the upper end. During the last week in August all of the important wholesale fish houses on the west and south sides of Lake Erie, from Detroit to Buffalo, were visited to obtain figures as to the magnitude and value of the carp fisheries of the lake. In November, 1901, about three weeks were spent on Lake Erie, principally at Port Clinton and Put-in Bay, in order to determine the relation of carp to the white-fish, which were in the height of their spawning season at this time.

In 1902 it was not practicable to begin the field work until after the 1st of July. As before, Lake St. Clair was first visited, but the conditions there being unfavorable on account of heavy storms, which made the water roily, investigations were renewed on Lake Erie, especially at Port Clinton and at Sandusky. During the last season of the investigations, in the summer of 1903, with headquarters in Sandusky, the work was conducted for about three weeks, during the spawning season of the carp, most of the time from a camp in the marsh, some 20 miles above the city, near where the Sandusky River opens into the large bay of the same name.

In addition to the observation of the general habits of the carp in waters where it has become adapted to a new environment in such a short time, several special problems were kept in mind. Thus a study

was made of the abundance and distribution of carp in relation to the conditions existing at various places, and measurements and records were taken to determine if possible whether the fish had changed perceptibly in accommodating itself to these conditions.

Most of the time, however, was given to the more strictly economic side of the question, and hence, either on account of their uncompleted state or because of their technical nature, the results of certain lines of the study have been omitted from the present report. One of the more strictly economic questions was the relation of the fish to aquatic vegetation, the destruction of which was being deplored, particularly by sportsmen, who maintained that the best food of many of the ducks, such as the canvasback and redhead, was fast being destroyed by the carp. It was also to be determined how far, if at all, carp interfere with the spawning of other fishes, and whether they eat the eggs and prey upon the young of other fishes, and if so, to what extent. It was claimed that they were especially detrimental to bass and white-fish—the former one of the greatest favorites of the sportsman, the latter one of the most valuable food-fishes of the Great Lakes.

Offsetting the possible harm done by the carp to vegetation and to the fisheries must be its own value as a food-fish; for the carp fishery has within the last few years, in the regions of the carp's greatest abundance, grown to be an industry of no mean proportions. Must the carp, then, be unconditionally condemned, or should we find that, if properly utilized, its value would compensate for the degree of damage it undoubtedly does? It is hoped that the conclusions reached in the following pages may do much toward settling this question, though there are still many points upon which fuller information is desirable.

In order to make the report more useful to those who are interested in the carp, it has been thought best to include a general description of the fish, its habits, and its history. The figures of the different varieties of carp here reproduced (pl. 1) are from drawings made for the Bureau of Fisheries from fish in its ponds in Washington soon after the introduction of the species into this country. The photographs and other figures are by the author.

It is impracticable to mention here all to whom I am indebted for assistance of one kind or another in the prosecution of my investigations. I am under especial obligations, however, to Messrs. Cleaver, of the firm of R. Bell & Co., Port Clinton, who not only furnished me a place in which to work in their fish house, but placed at my disposal, without cost, whatever carp were necessary for my work. The Bense Fish Company (which has since changed hands), of the same city, extended to me similar privileges. It was frequently necessary for me to call upon Mr. S. W. Downing, superintendent of the Bureau of Fisheries hatchery at Put-in Bay, for aid, which was furnished with

uniform courtesy. Through the kindness of Prof. Herbert Osborn I was enabled, when in Sandusky, to make my headquarters at the Lake Laboratory of Ohio State University, where I had the use of a table for considerable periods during the summers of 1901 and 1902. And, finally, I wish to express my gratitude to the many fishermen who took great interest in my work, who gave me whatever information was at their disposal, who permitted me to accompany them on their fishing trips, who shared with me their food, and who were my companions in camp for weeks at a time. Other special acknowledgments have been made in their proper places throughout the report.

THE SPECIES *CYPRINUS CARPIO* LINNÆUS.

DESCRIPTION.

Within the past decade the carp has become so generally distributed throughout the United States and so abundant in some places that nearly everybody is more or less familiar with it in a general way, but it has been almost universally neglected in the descriptive works in this country, further than a simple statement of its occurrence. It may therefore be well to give a brief description of the carp and its principal varieties.

The carp belongs to a family of fishes (Cyprinidæ) best represented in America by the minnows (especially of the genus *Notropis*) which abound in most of our lakes and streams. In the eastern United States the members of this family are all small, the largest rarely attaining 18 inches in length, while the smallest is scarcely 2 inches long when adult. The Old World species are generally much larger than this, and on the Pacific coast there are a few which reach a length of 5 or 6 feet, and which are also apparently more closely related to the European forms in structure.

Scientifically the carp is known as *Cyprinus carpio*, the name given to it by Linnaeus. It varies greatly in many of its characters, a condition probably brought about in large part by its state of domestication, or semidomestication, for a number of centuries. In shape it varies from a long, rather slender fish (pl. 1), whose height scarcely equals one-fourth its length, to a deep form nearly or quite half as high as long. The greatest height is at the anterior end of the dorsal fin. In all cases, however, the body is rather strongly compressed laterally, the cross section never approaching close to circular. The greatest breadth is normally a short distance back of the head, but the bodies of female fish are often, before the breeding season, distended with roe to a considerably greater breadth. This dimension in normal individuals usually equals less than half the height. The snout is blunt, and in typical forms the dorsal outline rises from the snout in a nearly uniform bow or arch to the base of the dorsal fin.

The length of the head, from the tip of the snout to the posterior edge of the gill-cover or operculum, is in the neighborhood of one-fourth the length of the fish^a, but is usually considerably less than the height. It varies considerably in individuals and with age. The eye is situated slightly less than halfway back on the head and on a line from the tip of the snout to the upper end of the branchial opening. The eyes are not quite circular, but are elongated slightly in a direction parallel to the dorsal side of the head, and their long diameter is contained six to seven times in the length of the head. The mouth when closed is nearly horizontal, the gape reaching about halfway to the anterior margin of the eye. At the corners of the mouth are two short barbels, usually a little longer than the diameter of the eye, yellow or reddish in color, which are, however, longer than two olive colored ones on the upper jaw. Both sets are variable, and, according to Seeley (1886, p. 95), may be unsymmetrical on the two sides or frequently wanting entirely.^b The lips are rather thick and fleshy, adapted to vegetable feeding, the lower somewhat shorter than the upper. The tongue is smooth. The palate is covered with a white and very sensitive skin ("carp's tongue"). The nostrils lie immediately anterior to the eyes and are double, those of each side being separated by a small projecting flap of skin. The anterior nostril is the larger.

The dorsal fin arises anterior to the median point in the length of the fish and slightly in advance of the ventrals, and extends back even with the posterior end of the anal fin. The base of the dorsal fin equals rather more than a third of the length of the body, and its greatest height (at the second and third soft rays) is equal to about a third of its length. After the first two or three soft rays, of which there are 18 to 22 in all, the remainder are only one-half to two-thirds as high, so that the free margin of the fin has a rather sharp reentrant angle at this point. Three or four (usually three) spiny rays precede the soft rays, the most posterior one being the stoutest and longest, with the extreme end usually soft and flexible; this soft portion is often broken away in older fish, however, leaving the ray with a hard, sharp point. The posterior border of this ray is serrated, the serrations or teeth, which have their points directed downward, lying on each side of a median groove and increasing in size from below upward.

The height of the anal fin is greater than its length at the base, which is about equal to one-fourth the length of the base of the dorsal. It is composed of 3 spiny rays and 5 or 6 soft, articulated rays. The second stout, spiny ray is similar to that of the dorsal fin. The first of the

^aThroughout the description "length" is considered from the tip of the snout to the *base* of the caudal fin, or, more strictly speaking, to the posterior edge of the hypural bones, which is found in practical measuring by cutting the flesh away a little and probing with a steel point. For general purposes this measurement can be taken to the last scale in the lateral line.

^bI, myself, have noted no cases in which they were absent.

soft rays is the longest, and the succeeding ones decrease gradually in size to the last, which is about one-half the length of the first.

The ventral or pelvic fins are made up of 2 spiny rays each, a long and a short one, and 8 or 9 soft rays. The height is much greater than the length at the base, but when folded back the fins do not reach as far as the beginning of the anal fin. The pectoral fins have each 1 stiff ray and 15 or 16 jointed ones, are rather elongated with rounded extremity, and reach back almost to the base of the ventrals.

The caudal fin is large, broad, and equally lobed, with the ends of the lobes rounded. The posterior notch is rounded, not very acute, and extends in half the length of the fin or less. It is made up of 18 or 19, or occasionally only 17, jointed rays, not counting the short incomplete rays (usually 4 to 6) outside the first long one on each side. The longest rays of the caudal fin are usually shorter than the head, and never exceed it in length.

The body of the typical scale carp is uniformly covered with large thick scales which approach a polygonal, four or five sided outline. In the lateral line, which extends nearly straight from the upper angle of the opercle to the middle of the base of the tail, or may be bowed slightly downward, there are 35 to 39 scales. Above the lateral line are 5 or 6 rows, and below a similar number. The scales are largest on the anterior part of the sides, where their diameter equals about one and one-half times that of the eye. Usually less than one-fourth of the scale is exposed; this portion is thicker and has a radial, fanlike ornamentation. The portion of the scale which is concealed by those in front of it is marked by fine concentric lines, which in turn form bands of varying width and regularity, and which are correlated with the growth of the scale. The middle of each scale of the lateral line is traversed by a small oblique or slightly curved tube, in which the sense organs of the lateral line are situated, and the cephalic canals of the lateral line system are noticeable on the suborbital ring.

In coloration the carp is fully as variable as in its other characters. In general the sides are yellowish, golden, or greenish, shading into a darker color on the back, which may be dark olive, or bluish-green, or almost black with a greenish cast. The yellow of the sides often becomes richer, approaching to orange on the ventral side between the anal and caudal fins. The yellow of the sides shades into whitish on the belly. The posterior edge of each scale has a dark border, and there is usually a dark blotch on the anterior part of the exposed portion, the two together forming a reticulated, or netlike pattern over the fish, with a dark spot at the anterior angle of each mesh of the net (fig. 1, pl. 1). The lips are yellow or orange; the rest of the head is dark olive, except the cheeks, which are yellowish, while the under side of the head is light yellow or whitish. The iris is yellow.

The dorsal fin is olive or dark gray, each interray space being

darker in its posterior half; the rays themselves are of about the same color. The anal is yellowish-red, while the pectoral and pelvic fins are grayish or yellowish, tending to red toward their tips. The upper lobe of the caudal fin is of about the same color as the dorsal; the lower lobe has a lighter, yellowish cast, with more or less red, especially toward the end.

The coloration is influenced by the age of the fish, the character of the water in which it lives, its nutrition, the season of the year, its sexual condition, and by the other conditions of its environment. Seeley (1886, p. 97) states that unsymmetrical coloring is sometimes found and that a fish may have glittering golden stripes on one side of the body and pale steel blue on the other. Sometimes typical carp are black, bluish, green, red, golden, silvery, or even white, and Doctor Fatio records that he has kept in confinement carp which were originally green or golden, but which became colorless in an opaque vase. It is not an unusual thing to see in carp that have died out of water a reddish suffusion, especially marked in the fins, probably due to the congestion of blood in the capillaries as the circulation is stopped.

In common with the other members of the family, the mouth of the carp is without teeth, the only organs of this description being the blunt, knob-like structures lying on the pharyngeal bones in the back part of the mouth, or "throat." These are entirely for grinding food, and, as is obvious both from their position and shape, are of no use in grasping, this function being performed by the so called lips. The alimentary tract is comparatively long, but uncomplicated; the stomach is a simple tube not sharply differentiated from the esophagus and without a blind sac, while the intestine has no pyloric appendages. The entire alimentary tract from the beginning of the stomach^a is usually two to two and one-half times as long as the body. The air bladder is large, with tough, thick walls. A transverse constriction divides it into two parts; the posterior of these is the smaller and ends in a rounded point, while the anterior portion is larger and has its base somewhat bilobed.

RACES AND VARIETIES.

The great range and frequency of variation in the carp is undoubtedly largely due to its domestication or semidomestication since early times. As is to be expected, this has resulted in the naming of a large number of varieties or races. In Europe, where carp culture is carried on systematically, these races are kept pure and true, so far as possible; but in this country no attention has been paid to them, at least in recent years, so that we need not treat them in detail here. Those interested in the subject will find an exhaustive account in the contribution entitled "*Über Karpfenrassen*," by Dr. Emil Walter, in

^a The position of the thoracic septum is here taken as the beginning of the stomach.

the recent book by Knauthe (1901). These names have often been given specific value and were bestowed usually either for characters of the integument or of form (cf. Günther, 1868, p. 26); thus we have such names as *Cyprinus macrolepidotus*, *C. rex cyprinorum*, *C. specularis* (for the mirror carp), *C. nudus* (leather carp), and *C. cirrosus*, *C. regina*, *C. hungaricus*, *C. clatus*, *C. acuminatus*, etc., and *C. hybiscoides*, a variety with the fins much prolonged. This list of synonyms might be extended much further.

Hessel (1881) considers all the varieties of carp as falling into three chief groups, which he distinguishes as follows (op. cit., p. 867):^a

1. *Cyprinus carpio communis*, the scale carp; with regular, concentrically-arranged scales, being, in fact, the original species improved.

2. *Cyprinus carpio specularis*, the mirror carp; thus named on account of the extraordinarily large scales, which run along the sides of the body in three or four rows, the rest of the body being bare.

3. *Cyprinus carpio coriaceus*, or *nudus*, the leather carp; which has on the back either only a few scales or none at all, and possesses a thick, soft skin, which feels velvety to the touch.

Walter (Knauthe, 1901), however, says the scale, mirror, and leather carp must not be considered as distinct species or races, although the conditions of the scales are characteristic, since a similar differentiation of the scales, or at least a tendency to it, is found in every true race of carp. In many ponds where one of these forms (i. e., scale, mirror, or leather) has been raised, the others have appeared spontaneously. He concludes that they should be considered only as varieties. He goes on to say that the ordinary characters are so inconstant and variable that sharp lines can not be drawn between the various intergrading races. In his opinion, the division into races should depend principally upon the relations in size of various parts or measurements of the body, though he correlates with this set of characters three others, viz, (1) rate of growth (i. e., the ability for rapid growth); (2) adaptability to climatic changes, and (3) time of sexual maturity. He then develops a rather artificial classification, depending mostly, as he says, upon the two ways in which the flesh is disposed upon the back; that is, whether there is a large development of the dorsal musculature, forming a highly arched outline, often with a hump and a recentrant angle back of the head, or whether the dorsal outline is low and comparatively straight. He uses as a measure of this the ratio of the height of the body to the length. This ratio is designated by the letter V in the following classification, translated from his paper (p. 85):

I. Cultivated races; $V=1:2$ to $1:3$.

(a) High-backed cultivated races; $V=1:2$ to $1:2.6$.

(b) Broad-backed cultivated races; $V=1:2.61$ to $1:3$.

II. Primitive and degenerate races; $V=1:3.01$ to $1:3.6$.

Here belong also those forms under the size ratio $1:2$ to $1:3$ which do not have a breadth in correspondence with their size ratio.

^a The blue carp, so called, is probably but a color phase, and not a true "variety."

It seems probable, however, that the character of the scales should be placed with the other four categories of characters given above as being another modification brought about by artificial breeding and selection and not as a condition due simply to conditions of domestication, as is sometimes supposed. All of these characters are probably heritable, although some of them, such as rate of growth and time of sexual maturity, may undoubtedly be readily influenced by external conditions in the individuals of a single generation. Furthermore, there apparently can be all combinations of these characters, and the so-called different varieties and races are the fish possessing the various combinations. In general, it may be said that the most highly specialized carp are those which are destitute of scales, which grow quickly, are high in proportion to their length, and tend to have a hump back of the head, and which become sexually mature at an early age.

These various forms of carp probably differ in no essential way, except that they are not so well differentiated and established, from what are spoken of as "breeds" by stock breeders. There would appear to be no valid reason for calling those with the different character of scales "varieties," and to class those which are differentiated as to form as "races." It is merely that the most obvious characters are those which have become most permanently established by selection, namely, character of scales first and form second. Walter claims that ability for quick growth has also been fixed in certain stocks. Thus a fish of good quick-growing stock may later make a good growth even if poorly nourished during its first or second year, whereas a fish of poor stock under similar conditions would be permanently stunted. The hardiness, or ability to resist climatic conditions, he says has not yet been made permanent in any stock, though it is claimed that scale carp possess the ability to a greater degree than the others. The adaptability to climatic conditions probably becomes reduced rather than increased as the other characters are developed.

All intermediate stages are found in the sets of characters mentioned. For example, fish may be entirely covered with scales, but the scales are larger and fewer in number than on the regular scale carp, and, similarly, one finds all gradations between the leather and the mirror carp. The same thing is true of the form of the body. This is especially the case with the fish in our waters, where all kinds have become established and have interbred until there is a complete series in the gradation of characters in almost any lot of fish taken, and a division of them into varieties must be an arbitrary one. As a matter of convenience in my work, those fish which had larger and fewer scales than typical scale carp I called mirror carp. Some authors state that the leather carp should be entirely destitute of scales; others that it may have a row of scales along the back and a row on each side. In no case in the Great Lakes did I see a carp entirely

destitute of scales, and those which are nearly bare are few compared with those entirely scaled. Of nearly 3,000 fish counted at random at various times and at different places about Lake Erie, something over 91 per cent might be called scale carp, and I should judge that at Lake St. Clair the percentage was even higher. It is very probable that under the present free conditions of life of these fish, with the constant interbreeding, they are gradually returning to the primitive scaled condition, and although there are no data to show the rate at which this process may have been progressing since they have become established in our waters, a few years more may see an even smaller proportion of mirror carp than there is at present.

HYBRIDIZATION.

Not only does the interbreeding of the different varieties of carp (using the word "variety" in its broad sense) cause confusion, but all these varieties cross readily with certain closely related species of fishes, giving rise to a number of hybrid forms. The commonest of these is a cross between the ordinary carp and the so-called crucian carp (*Carassius vulgaris*), a common fish in Europe. The resulting hybrid was described as a distinct species before its true nature was known, and was given the name *Carpio kollarii*. It is often known in Germany as the "poor man's carp." In general it is intermediate in character between its two immediate ancestors, but often resembles *Cyprinus carpio* so closely that it can be distinguished only with difficulty. Hessel (1881, p: 868) made the following experiments in crossing in order to settle the question of what resulted from the various crosses. He says:

In order to determine this question, I myself managed to bring about such crosses by placing (1) female common carp with male crucian carp, and (2) female crucian carp with male common carp, in small tanks, constructed with this end in view; (3) I also put together female *Carpio kollarii* with male common carp; this for the sole purpose of testing the capability of propagation of the *C. kollarii*, which had been doubted. In the two former cases I obtained forms analogous to the *Carpio kollarii* sometimes approaching in appearance the true carp, at others the crucian carp. In the third case, however, having placed ripe *Carpio kollarii* together with *Cyprinus carpio*, I obtained a product with difficulty to be distinguished from the genuine carp. I took the trouble to feed them for three years, in order to try their fitness for the table, but their flesh was exceedingly poor and very bony and could not be compared by any means to that of the common carp.

Hessel remarks upon the frequency of this cross throughout Europe, and says that in many instances it is cultivated by pond owners, who suppose that they have the true carp. So far as I am aware the crucian carp has not been introduced into this country. But the carp is also said to cross readily with the gold-fish (*Carassius auratus*), tench (*Tinca tinca*), and some others. The first of these is already abundant in some of our waters, though the others have not as yet, at any rate,

become well established.^a This is a matter of considerable importance, for whatever may be our opinion of the carp as a food fish, we certainly do not want it any poorer than it is. For this reason it would seem that efforts should be made to prevent the introduction of the crucian carp in our waters, and to restrict, so far as possible, the spread of gold-fish, tench, and other fishes with which the carp may hybridize with a resulting deterioration of the food value of the race.

SIZE, GROWTH, AND AGE.^b

There appears to be but little definite information as to how long carp may live, and what size they may attain. It is said that they may live to be 100 or even 150 years old, and may come to weigh 80 to 90 pounds, but these statements are generally based upon insufficient evidence. That the fish do commonly reach a weight of 30 to 40 pounds, however, seems quite certain, and Hessel (1881, p. 874) says: "It is a well-known fact that two large carps, weighing from 42 to 55 pounds, were taken several years ago on one of the grand duke of Oldenburg's domains in Northern Germany," and also claims to have had in his possession some scales $2\frac{1}{2}$ inches in diameter, which came from a Danube carp that weighed 67 pounds.

The largest carp I have myself seen from the Great Lakes would not weigh much over 20 pounds. That the fish do attain a much larger size is, however, certain. Mr. W. Cleaver, upon whose information I can rely, tells me that in the spring of 1903 he received from Sandusky Bay a female carp which weighed 30 pounds after spawning. According to the ratio between the weight of the ova and the entire weight of the fish found in another case, before spawning this fish would have weighed, in all probability, fully 37 pounds. From the fishermen, both at Lake St. Clair and at Lake Erie, I often heard of carp weighing 30 and 40 pounds, but these were only estimates and not based on actual figures. That there are at present to be found in these waters carp weighing more than 40 pounds I doubt.

As has already been stated, the rate of growth of carp (as is true of most fishes) depends in a great measure upon the temperature of the water in which the fish lives and the abundance of suitable food. Under ordinary conditions in open waters of temperate regions they will reach a weight of 3 to $3\frac{1}{4}$ pounds in three years (Hessel, 1881, p. 873),

^a Goode (1888, p. 418) says the tench has become well acclimatized in the Potomac. Dr. H. M. Smith, however, informs the writer that the tench is not numerous in the Potomac, but the gold-fish is abundant and has become one of the regular market fishes at Washington. It has lost the brilliant coloration it had when it escaped from the Government ponds, and now has the dull brown color of the primitive type; the fish is not recognized in the market, and is sold under the name of "sand perch."

^b It is maintained that the age of carp may be told with considerable accuracy by means of the successive lines of growth upon the scales, similarly to the way that the age of a tree is determined by counting the annular rings. Persons interested in this subject will find a full discussion of it by Dr. Emil Walter in the book on carp-culture by Knauthe (1901), chapter III, pp. 88-122, "Die Altersbestimmung des Karpfens nach der Schuppe."

but in warmer climates the growth is very much more rapid, and sexual maturity also is attained at an earlier age. Numerous examples of the rapid growth of carp in the warmer waters of this country have been reported. Thus in a report of the Illinois Fish Commission (Illinois, 1884, p. 10) will be found the following statement by Doctor Adams, of Spring Hill Park, Peoria, with regard to some fish received by him from the State:

At less than 2 years of age one of the carp weighed 9½ pounds, measuring 22 inches in length, a growth of over 1 pound a month from the time it was placed in warm water.

Doctor Adams had previously had the fish in a spring where the water was cold, and they had not done well. Many more statements may be found in the early reports of the United States Fish Commission.

Goode (1888, p. 414) takes from Cholmondeley-Pennell's "Fishing" the following very good table giving the comparative weights and lengths of carp:

Length.	Weight.	Length.	Weight.	Length.	Weight.
<i>Inches.</i>	<i>Lbs. Oz.</i>	<i>Inches.</i>	<i>Lbs. Oz.</i>	<i>Inches.</i>	<i>Lbs. Oz.</i>
9	7½	17	3 4½	25	10 6½
10	11	18	3 14½	26	11 11
11	14½	19	4 9	27	13 2
12	1 2½	20	5 5½	28	14 10
13	1 8½	21	6 2½	29	15 4
14	1 14½	22	7 1½	30	16 0
15	2 4	23	8 11½		
16	2 11½	24	9 3½		

THE COMMON NAME.

For the sake of completeness a word as to the name of the carp may not be out of place. According to Day (1880-1884, p. 159):

Carp has been derived from the Greek term "kuprinos," itself said to be from "kupris" or "Cyprus," where Aphrodite or Venus was first worshiped, and may have been given to this fish in order to symbolize its extraordinary fecundity. Holme (1688) gives *scizling* as yearlings, next a *sprole* or *sprale* from 2 years of age, terms taken from Gesner's Swiss names of this fish, they not being called "karpi" until 4 years old. In the last century we are told (Whole Art of Fishing, 1719) it was called the *fresh-water fox* and *queen of rivers*. *Cerpyn*, Welch. *De Karper*, Dutch. *La carpe*, French.

In the United States it has come to be generally known as the German carp, because of its importance in Germany and its introduction here from that country. Some protest has been made against the use of the name, as the carp is not in the strict sense a German or even a European fish, but, like the term English sparrow, it is a name that is likely to persist. Both of these names are historically appropriate, so far as we are concerned, since they serve to indicate the source of the first^a lots of each species introduced. In ordinary usage, however, simply the word "carp" is used, and it is so that the fish is known commercially.

^aThis is leaving out of consideration the rather doubtful introduction of carp into the Hudson River from France by Captain Robinson about 1830 (see p. 540).

THE CARP IN EUROPE.

The little that is known of the early history of the carp is given, with slight variation, in nearly all works which treat of the fish, and as I have nothing to add I shall here give merely a brief summary. There seems to be a general agreement that carp were indigenous to the temperate portions of Asia; and they had probably spread into southeastern Europe before the Christian era. Aristotle speaks of it as "a river fish without a tongue, but having a fleshy roof to its mouth; as producing eggs five or six times a year, especially under the influence of the stars; as having eggs about the size of millet seed; and as being occasionally struck by the dog-star when swimming near the surface" (Houghton, 1879, p. 15). It is also mentioned by a number of other writers of early times and is spoken of as an excellent article of food.

The carp probably came into western Europe by easy stages. Hessel states that its culture in Austria can be traced back as far as the year 1227, and it is claimed to have been introduced into Germany and France two or three decades later (1258). The extensive ponds at Wittingau, in Bohemia, were begun as early as 1367. Carp culture was carried on especially in connection with monasteries and on a number of large estates, and has come to be an important commercial industry, especially in Austria-Hungary and Prussia. It is said that an acre of water suitable for carp culture will rent for as much as an acre of land. The fish's range has gradually extended in Europe, until now it is found over practically the whole of the continent from Italy to Sweden and Norway, and from France and the British Isles to Russia and the boundaries of eastern Siberia. It does not do so well, however, and is little cultivated, in the more northern portions of its range, such as Scotland, Sweden, Norway, Finland, etc.

Peyrer (1876, p. 615) states that in Austria the "Danube carp" was once a favorite and cheap food of the common people, but that its numbers have become greatly decreased. A writer (Anonymous, 1880) whose paper has been translated in the Report of the United States Fish Commission for 1878, and Veckenstedt (1880) have given good descriptions of the carp fisheries of the Peitz Lakes in Nether Lusatia, some 60 to 80 miles to the southeast of Berlin. There are some 76 of these lakes, which are a royal domain and are rented to a private individual at an annual return equivalent to \$12,870. The ponds are drawn in October, and this is the occasion for a general holiday in the region. The drawing off of the water is begun three weeks beforehand, and when the fish have congregated in the deeper places they are taken by means of large drag-nets, or seines, capable of holding 5,000 pounds of fish. At Cottbus, a near-by city, meets the so-called "Carp Exchange," composed of buyers from the large firms in Halle, Leipzig, Dresden, Magdeburg, Posen, Berlin, etc. The

raisers also convene to determine the price that shall be asked for carp. It is stated that from 200,000 to 300,000 fish are sold at Cottbus in a season, representing an aggregate weight of 800,000 to 1,000,000 pounds. After being weighed the fish are transferred to perforated boats—what we would call live-cars—and are transported down the canals and rivers to the large cities, where they are to be consumed. This is a slow and laborious journey, the cars often having to be carried over shallow places on rollers, and a week is required to get the fish to Berlin, while to reach Hamburg and Magdeburg takes four or five weeks. This is in striking contrast to our method of packing the fish in ice and shipping them 500 miles or more to market in a couple of days. The German method has the advantage of getting them there alive.

Just when and whence the carp came into England is not known. It is generally conceded to have reached there, however, between 1051, when it was not mentioned in the Anglo-Saxon Dictionary of Ælfrie, and 1486, the date of first publication of the "Boke of St. Albans," where it is spoken of as "a deytuous fysshe: but there ben but fewe in Englonde" (see p. 529). Linnaeus puts the date of introduction into England as 1600, and it is sometimes attributed to Mascall^a in 1514; but probably he is responsible only for the extension of the range into Sussex (Day, 1880-1884, p. 163). In the privy purse expenses of King Henry VIII, in 1532, various entries are made of rewards to persons for bringing "carpes to the king" (Yarrell, 1836, vol. i, p. 306, from Pickering's edition of Walton, p. 207, note). All recent writers agree that the oft-quoted "doggerel lines of—

‘Turkies, carp, hop, pickerel, and beer
Came into England all in one year’

may be considered interesting as verses, but not faithful representations of facts."

Day (1880-1884, p. 163) gives the date of the introduction of carp into Sweden as 1560^b and into Denmark as 1660; but de Broca (1876, p. 279, footnote) says they were taken to Denmark more than a hundred years earlier, in 1550, by Pierre Oxe. Malmgren (1883), in an address to the bureau of agriculture of the imperial senate of Finland, advises against any attempt to raise carp in that country, as he thinks that on account of the climatic conditions it would not pay. They were introduced into Finland in 1861, when Chamberlain Baron v. Linder placed some in the ponds of his estate of Svartå, but they are said to have died out after a few years. Some attempts were made prior to 1861, but they were all failures. Malmgren says that Holstein and Courland are the most northerly countries where carp culture

^aSometimes written "Marshall."

^bIn his "Fishes of Malabar," Day (1865, p. xii) remarks: "Block observes that in his time, 1782, owing to the degeneration of the species in the north, due to the coldness of the climate, several vessels were yearly dispatched from Prussia to Stockholm with further supplies of live carp."

is successfully carried on, and that even in Schleswig the people complain of lack of success. Nevertheless, "in 1879 a landed proprietor in Schoren [the most southerly Province of Sweden] commenced to raise carp in ponds: and there is a reasonable prospect that this kind of fish culture, if carried on rationally and cautiously, will prove profitable, because carp can easily stand the climate in the southern part of Sweden" (op. cit., p. 377). However, all attempts of King John III to raise carp on the island of Oeland proved futile.

In Norway carp were, when Malmgren wrote, acclimatized in only two places—near Farsund, in the southernmost part of the country, and at Milde, near Bergen. In Russia they were said to be found in some of the imperial ponds near St. Petersburg and near the convent of Walamo, but there was no attempt at carp culture.

These records of the northerly extension of the carp in Europe are of interest when we compare them with its distribution in North America.

INTRODUCTION AND DISTRIBUTION OF CARP IN THE UNITED STATES.

It is uncertain when the first carp were introduced into the United States. This may have been done at any time by private individuals, though if such was the case the fish were probably only kept in tanks or small ponds as curiosities, for it is certain that with the exception of their establishment in California they never gained a general distribution or attracted much attention until their successful introduction by the Fish Commission in 1877. Certain early writers mention the presence of carp in American waters, but there can be little or no doubt that they have misapplied the name to some native fish. Thus, in the Report of the Commissioners of Fisheries of Massachusetts (Massachusetts, 1866), quoting the early colonists of New England, occur the following lines in reference to the Connecticut River:

In it swim salmon, sturgeon, carp, and eels,
Above fly cranes, geese, ducks, herons, and teal's.

And again, in his history of the Fisheries of Chesapeake Bay and its Tributaries, McDonald (1887) takes from the diary of Col. William Cabell, of "Union Hill," Nelson County, Va., the statement:

1769, Oct. 25: Caught 2 fine carp in our traps.

These traps were set in the James River, and in this case at least we can easily see what fish may have been mistaken for the carp, since the so-called carp-sucker (*Carpiodes cyprinus*), which in a superficial way greatly resembles the true carp, occurs abundantly in the waters of that region. A much more recent case is given by Clark (1887, p. 735), who takes from Ricketson's History of New Bedford^a (Massachusetts) the statement following.

^a1858, p. 403.

In 1858 the varieties [of fishes] to be found in the waters of New Bedford were: Fresh-water: Trout, perch (white, red, yellow), pickerel, chub, carp, silverfish, minnow, hornpout, eel, clam.

But as other evidence of the occurrence of the carp in Massachusetts at that time is lacking, we must again conclude that the identification was at fault.

In 1842, however, the name of the carp appears in scientific literature, being included by De Kay (pp. 188-190) in his list of the fishes of New York. He remarks upon its introduction as follows (p. 189):

I am not aware that any attempt has been made to introduce the carp into this country previous to the year 1831, which, it will be seen by the following letter from Henry Robinson, esq., of Newburgh, Orange County [New York], was attended with complete success,

"I brought the carp from France in the years 1831 and 1832, some 2 or 3 dozen at a time, and generally lost one-third on the passage. I probably put into my ponds 6 or 7 dozen. They soon increased to a surprising degree, and I have now more than sufficient for family use. I have not paid much attention to their habits, but I have noticed that they spawn twice a year; first about the middle of May, and again in July. It is said in France that they spawn three times, but I have not observed it. During the period of spawning, which lasts about ten days, it is very amusing to watch their operations. They come up to the surface, and the females deposit their spawn along the sides of the pond among the grass, where they are impregnated by the males as they are emitted. During this process, they keep the sides of the pond in a foam with their gambols, and it is not difficult at that time to take them with your hands. They grow quickly, reaching 3 or 4 inches the first year, but after that time their growth is very slow. The largest I have taken yet have not exceeded 10 or 11 inches, my ponds being too small for them to equal the size of those you see in Europe. They are very shy of the hook; I generally bait with small pieces of fresh bread, (of which they are very fond,) made up into small pills with the fingers, and at the same time drop a small piece of bread into the water near the hook, when they bite readily. My ponds are supplied by springs of pure and clear water, but they keep the water in such a state that they cannot be seen at the bottom.

"For the last four years past, I have put from 1 to 2 dozen carp every spring in the Hudson river near my residence. They have increased so much that our fishermen frequently take them in their nets. They are larger than those in my ponds."

There are several other references in the literature to apparently the same introduction. In the Transactions of the American Institute (1851) for 1850, page 397, in a discussion before the Farmers' Club, we find the following:

Mr. MEIGS.—We are pleased to see among us Captain Robinson, of Newburgh, who brought the Carp from England several years ago—thus conferring a great benefit upon his country by adding a fish before that unknown in our waters.

Captain ROBINSON.—I brought the Carp from France about seven ^a years ago, put them into our Hudson river, and obtained protection for them from our Legislature, which passed a law imposing a fine of \$50 for destroying one of them. I put in Gold Fish at the same time. Now some of these Carps will weigh 2 pounds, and some of the Gold Fish, which are a species of Carp, are quite large, some of them being pure silvery white. Both kinds are multiplying rapidly.^b

^a There is here a discrepancy in the date. If, as Robinson says in his letter to De Kay (above), he brought the carp to this country in 1831-32, seventeen years would come nearer to it than seven.

^b This discussion is noted by E. E. Shears (1882).

From both the preceding quotations it appears that Captain Robinson had been planting young carp in the Hudson regularly since their establishment in his pond. According to a writer in *Forest and Stream*, who signs himself "R." (1874), these were further augmented a few years before that date by the bursting of the dams of Captain Robinson's ponds. He says:

More than fifty years ago^a Captain Henry Robinson, owner of one of the Havre packets, brought the first carp and goldfish to this country from France. He placed them in a small pond on his place in the southern part of this village [Newburgh, N. Y.]. Several years ago, when the dam of the pond broke away, many of the fish escaped into the river. They appear to multiply very rapidly, and any number might be obtained from the fishermen about the bay.

Finally, in the *Bulletin of the United States Fish Commission* for 1882, we find the following letter (dated New York, May 31, 1882), to Professor Baird from Mr. Barnet Phillips (1883):

To-day Mr. James Benkard, vice-president of our fish cultural association, told me that his grandfather, Capt. Henry Robinson, had, about 1830, first brought carp from Holland [sic] and put them in his ponds at Newburg, and that he had therefore reason to suppose that the carp in the Hudson were derived from these. In Frank Forester's "Fish and Fishing," of 1849, page 166, you may find a statement to this effect, which Mr. Benkard says is substantially correct.

I have thought these data might be useful when the whole history of the carp in American waters is to be written up.

In spite of the positive statements in the foregoing quotations there still seems to be some question as to whether the true carp was found in the Hudson prior to the time of its introduction into the country by the Fish Commission. In the letter to Professor Baird from Mr. Shears (1882), dated January 26, 1881, and already quoted, he says:

I notice that the gold-fish are quite plenty in the river in this vicinity [Coxsackie, Greene County, N. Y.]; also a fish about the size and shape, which is called a silver-fish, but they do not correspond to Captain R[obinson]'s description of the silver-fish. These are nearly or quite as dark as a rock-bass. I have seen none that would weigh over one pound and a half. When caught in fykes by the fishermen, they are usually pronounced unfit to eat and thrown back in the river. However, last fall I saw them peddled through the streets, and the fishermen told me they could catch scarcely any other kind, and they sold as well as perch or bass. I have not had an opportunity to taste any of them, therefore am no judge of their flavor.

It is to be noted that he makes no mention of the carp. That Professor Baird was inclined to the opinion that there were no true carp in the Hudson is shown by the following paragraph taken from his report for 1877 (*U. S. Fish Commission Report*, 1879, p. *43):

Considerable discussion has arisen as to the person to whom the introduction of the carp into America is due; indeed, it is claimed that this was done many years ago. Certain fish-ponds on the Hudson River are said to have been emptied of their contents by a sudden freshet, and, as a consequence, the Hudson is now full of what

^a Here, again, there is a discrepancy in the date. The introduction of the fish could not have been more than forty-three years before.

is called the carp and sold as such in the New York market. I have not yet, however, been able to find a single fish among those sold as carp which is really any other than the common gold-fish, reverted to its original normal condition. Indeed, in the olivaceous fish caught in great numbers in the Hudson there are usually found precisely similar specimens of white, red, and all intermediate conditions. While, therefore, I can not say that no genuine carp were transferred to the Hudson, none have come under my observation; and it has occurred to me as possible that the Prussian carp, *Cyprinus carassius*, L., may have been the one introduced, or possibly the hybrid progeny of this and the true carp may have been gradually mixed with the gold-fish.

If we could know whether the description given by De Kay (1842, p. 188) was made by him from specimens taken in New York, or whether he merely copied what he gives from some European writer, we might be able to throw some light on this subject. Certain it is that his description disagrees in a number of points with that of the true *Cyprinus carpio*, but it is apparent that some of these are inaccuracies, as they do not agree either with the Prussian (or crucian) carp or with the hybrid, the so-called *Cyprinus kollarii*. The most important points in this connection are, perhaps, that he gives the length as 6 to 12 inches, and describes the "nape and back" as "rising suddenly." True carp in the second or third year, under ordinary conditions, should attain a length of more than 6 to 12 inches, while the hybrid rarely exceeds 8 inches in length (Seeley, 1886, p. 104). It is noteworthy, too, that Captain Robinson in his letter to De Kay (p. 540) states that his fish grew quickly, reaching 3 or 4 inches the first year, but after that time their growth was very slow, while the largest he had taken from his pond did not exceed 10 or 11 inches. He adds, however, that those subsequently taken from the river were larger than those in his ponds.

Even more significant, it seems to me, however, is the statement that the nape and back rise suddenly, for though this may be in some of the more highly cultivated races of carp, it is not usually the case, especially when they have bred out of the confinement of ponds for a time, where no artificial selection is made. On the other hand, the description forcibly suggests the broad shape of the hybrid mentioned, which in outline approaches the crucian or Prussian carp, *Carassius vulgaris*. That this last is not the fish meant by De Kay is shown by his statement that the fish has four barbels.

As matters stand, we shall probably never know whether the fish brought over by Captain Robinson were true carp or whether he happened when procuring the fish in France to get hold of specimens of the hybrid form, which occurs in abundance in many parts of Europe. It makes little difference which they were, however, since the comparatively little stock in the fresh waters of southeastern New York could have little influence on the multitude of fish, from a new importation, which was spread broadcast over the country a few years later.

The circumstances attending the successful introduction of the scale carp into California, in 1872, by Mr. J. A. Poppe, of Sonoma, are better known. Mr. Poppe left California for Germany in the spring of 1872. At a place called Reinfeld, in Holstein, he procured 83 carp of various ages and sizes (cf. Poppe, R. A., 1880, p. 663), the three largest of which were 2 feet or more in length, the smallest "the length of an ordinary steel pen." The fish were placed in 22-gallon tanks arranged one above the other, so that the water flowed down from the highest to the lowest, when it was dipped back to the top. These were put aboard a steamer for New York. Many of the carp died on the way, the larger ones going first, and only 8 reached New York alive. These were taken across the continent to San Francisco in safety, but 3 more were lost before reaching Sonoma, where Mr. Poppe arrived on the 5th of August, 1872, with only 5 of the smallest of the 83 fish with which he started. Ponds had already been prepared, and the surviving carp were placed in them at once. They did well from the first, and, according to Mr. Poppe in the report mentioned above, they spawned the next spring, by which time they had reached a length of 16 inches! It was estimated that in May (1873) there were in the ponds over 3,000 young carp. The young fish were sold to farmers throughout California and adjacent states, and some were shipped even to Honolulu and Central America. The report gives a list of persons in Sonoma County who undertook the culture of the fish, and states that at that time (presumably 1878) Los Angeles, San Bernardino, and the adjacent counties in the southern part of the state were well supplied with the fish, and reports were coming in from all quarters that they were doing remarkably well.

There seems to be some question, also, as to whether the fish introduced by Mr. Poppe were a pure strain, for Professor Baird (U. S. Fish Commission Report, 1879, p. *44), who examined some specimens that were sent to him, says:

These are scale carp, apparently somewhat hybridized; at least, they do not present the characteristics of the pure breed brought by Mr. Hessel:^a

He here refers to the fish introduced under the direction of the Fish Commission, the subject which we will now consider.

The question of the introduction of the carp into the United States was taken up by the Fish Commission within a few years after the organization of that Bureau. The first mention of it occurs in the report for the years 1872 and 1873 (U. S. Fish Commission Report, 1874, pp. lxxvi, lxxvii) under "Fishes especially worthy of cultivation." Professor Baird, at that time Commissioner, there says:

Sufficient attention has not been paid in the United States to the introduction of the European carp as a food-fish, and yet it is quite safe to say that there is no other

^a Goode (1888, p. 417) says: "Those [carp] introduced into California a few years ago by Mr. Poppe were an inferior strain of Scale Carp."

species that promises so great a return in limited waters. It has the pre-eminent advantage over such fish as the black bass, trout, grayling, &c., that it is a vegetable feeder, and, although not disdaining animal matters, can thrive very well upon aquatic vegetation alone. On this account it can be kept in tanks, small ponds, &c., and a very much larger weight obtained, without expense, than in the case of the other kinds indicated.

It is on this account that its culture has been continued for centuries. It is also a mistake to compare the flesh with that of the ordinary *Cyprinidæ* of the United States, such as suckers, chubs, and the like, the flesh of the genuine carp (*Cyprinus carpio*) being firm, flaky, and in some varieties almost equal to the European trout.

It was not the intention of the Fish Commission to introduce the carp into waters that were already stocked with good native species, nor was it claimed that the carp was superior to the majority of our indigenous food fish. But it was believed that it could be successfully raised in many sections of our country not favorable to the growth of better fish. In this connection Professor Baird remarks in a subsequent report (U. S. Fish Commission Report, 1879, p. *41):

There are several species of American *Catostomidæ* which might in all probability answer in some measure, if not fully, in place of the carp. Among them are especially the buffalo fish, a large sucker, the flesh of which is much esteemed. As, however, some special varieties of carp have been developed and had their instinct of domestication established, while experiments on our indigenous species are scarcely yet tried, there is no reason why time should be lost with the less proved species.

In another place (U. S. Fish Commission Report 1873-4 and 1874-5, p. xxxvi) he enumerates the good qualities of the carp which made it a desirable species for cultural purposes in the United States. These are given as follows:

1. Fecundity and adaptability to the processes of artificial propagation.
2. Living largely on a vegetable diet.
3. Hardiness in all stages of growth.
4. Adaptability to conditions unfavorable to any equally palatable American fish and to very varied climates.
5. Rapid growth.
6. Harmlessness in its relation to other fishes.
7. Ability to populate waters to their greatest extent.
8. Good table qualities.

Nearly all, if not all, of our American food fishes are carnivorous, preying for the most part upon smaller fish of all kinds. The increase of these forms is therefore necessarily limited, especially in small bodies of water, where it is difficult to keep them supplied with food. The large-mouthed black bass (*Micropterus salmoides*), which has been extensively used for stocking rivers and lakes throughout the country, is a good example. But where strictly a food fish was required, it seemed that one at least in large part a vegetable feeder possessed far greater advantages, and, as stated above, no native fish answered these requirements so well as the carp.

In the winter of 1876-77, Mr. Rudolph Hessel, in the interests of the Fish Commission, as an initial experiment shipped carp from

Bremen to Baltimore, but, owing to a storm of unusual severity to which the vessel was exposed, all were lost on the way. He immediately returned to Europe, however, where, at Höchst, near Frankfurt, he procured another lot of fish. These he succeeded in bringing in safety to New York, and on May 26, 1877, they were placed in ponds in Druid Hill Park, Baltimore. This lot consisted of 345 fish, of which 227 were naked and mirror carp, and 118 were common scale carp. The ponds at Druid Hill Park not being sufficient for the proper care of the fish, Congress allowed use to be made of the Babcock Lakes in the Monument lot, in the city of Washington, and appropriated the sum of \$5,000 to put these in proper condition. In the following spring these ponds were ready for the reception of the fish, and 65 leather carp and 48 scale carp were transferred to them from the Druid Hill Park ponds.

The fish that remained in Baltimore, under the care of Mr. T. B. Ferguson, spawned in 1878, but some gold-fish had entered the pond accidentally, and the carp hybridized with these, so that instead of having young true carp there were some 2,000 hybrid young. These were destroyed as being worthless. The results were more satisfactory in 1879, in which year about 6,000 young were reared. Of these, 2,750 were distributed to applicants throughout Maryland, the remainder in other states. In this year the fish in the ponds at Washington spawned for the first time, and about 6,000 were also reared there. Altogether, in 1879, some 12,265 carp were distributed to over 300 persons in 25 states and territories. Among the recipients were various state commissioners, who redistributed their fish to applicants in their respective states.

Applications for carp had begun to come in as early as the fall of 1876, and the number increased rapidly in the succeeding years. In 1877 there were 22 applications, in 1878 144, and in 1879 235, while in 1880 there were nearly 2,000.

In 1879 new ponds were constructed at Druid Hill Park, and it was in this year, also, that a new importation of carp was made from Germany. These were brought over by Dr. O. Finsch (1882), a German naturalist, who obtained 100 mirror carp from Mr. Eckhardt, of Lübbinchen. These were small fish, a year and a half old and only 6 to 8 inches long. Only 23 reached New York alive, although the water was aerated by pumping air into it, and ice was used to keep the temperature down. The fish were shipped from Hamburg in coal-oil barrels, and Dr. Finsch attributes the large mortality to the fact that one of the barrels was not clean, and to the warm weather. The survivors arrived in New York on the 6th of May, whence they were shipped to Washington without loss and turned over to Mr. Hessel, the superintendent of the Washington ponds.

In the succeeding years the demand for carp steadily increased, and the fish were furnished in great numbers by the Fish Commission, being sent to all parts of the United States, and some shipments being made to other countries. We find in the reports of the Commission that in several successive years carp were sent to Canada, and in 1882^a they were also distributed to persons in Ecuador, Costa Rica, and the City of Mexico. In 1882 over 7,000 applications for carp were filed, and 5,758 applicants were supplied with 15 to 20 carp each, 143,696 fish being distributed in this way. With an appropriation of \$12,000 made by the Forty-sixth Congress, the breeding ponds were extended until there were some 20 acres of ponds devoted to raising this fish.

In this year, also, an attempt was made to bring carp eggs to this country. On May 31, Mr. George Eckhardt arrived from Germany with two cases of carp eggs, packed after a method that had been found successful for transportation for shorter distances; but when the eggs were examined here they were found to be dead and covered with fungus. The effort had been made only as an experiment, and was so far unsuccessful, on account of the long time required for the journey, that it was not repeated. Another importation of the adult fish, however, is recorded in 1882, when, as a return for favors extended to the Deutsche Fischerei-Verein, Herr von Behr forwarded to the Commission a number of the so-called blue carp, "a variety believed to be of particular interest, and which has not been hitherto cultivated by the Commission." When these arrived on January 4, 1882, it was found that 19 of them were of "pure blood," while 4 were hybrids. The hybrids were destroyed and the others turned into the Government ponds.

As illustrating how thoroughly carp were disseminated throughout the United States in these early years of its introduction, the data for 1883 furnish an interesting example. In that year carp were sent into 298 of the 301 Congressional districts, representing 1,478 counties; in this way 260,000 carp were distributed, in lots of 20, to 9,872 applicants. The distributions continued large until about 1890, when they began to diminish, and were finally discontinued in 1897. The following table gives the approximate figures for the distribution from 1880 to 1896:

^a Records taken from United States Fish Commission reports have reference to fiscal years beginning July 1. Distributions of carp were made in the fall of the calendar year preceding the date designating the fiscal year—i. e., distributions in the fiscal year 1882 were made in the fall of the calendar year 1881.

Carp distributed by the United States Fish Commission.

Fiscal year.	Number of fish.	Fiscal year.	Number of fish.
1880	12, 265	1889.....	170, 402
1881	66, 165	1890.....	26, 316
1882	143, 696	1891.....	338, 809
1883	259, 188	1892.....	157, 093
1884	162, 000	1893.....	72, 481
1885	167, 948	1894 ^a	47, 757
1886	348, 784	1895.....	33, 935
1887	133, 769	1896 ^b	87, 203
1888	175, 410		

^a In 1894 400,000 young carp were used for feeding bass.

^b In 1896 about 600,000 young carp were used for feeding bass, and since that date all the carp hatched by the Government have been used for the same purpose.

At the present time the carp has come to have a very general distribution, especially in the temperate portions of the world. Its distribution in Asia and Europe has already been mentioned (p. 537). It is now found in abundance all over the United States wherever the waters are at all suitable. Many were sent to Canada by this Government shortly after the introduction of the species, but with the exception of some of the waters of Ontario, especially in the vicinity of the Great Lakes, it does not appear to have become very abundant, owing without doubt to the coldness of the waters. From this country a number of lots were sent to Ecuador, Costa Rica, and Mexico, where it was said to be thriving. It was introduced into the Hawaiian Islands from California, and Cobb (1902, p. 452) reports it as being found now on the islands of Maui and Kauai. On the former it is quite common in the irrigation ditches near Wailuku, where it is said to have been first planted. The fish are not often sold, as they are not popular with the whites and natives on account of their muddy flavor, but they are caught and eaten by the Japanese and Chinese.

In reference more particularly to the history of the carp in the Great Lakes region, there can be little doubt that prior to 1879 there were no carp here. In that year the first distribution was made by the United States Fish Commission, and those who received fish were 6 applicants in Ohio, 5 in Indiana, 2 in Illinois, and 1 in Wisconsin. In the following year a large number of persons in these states received carp either directly from the United States Commission or indirectly through their state commissions, and the real introduction of this fish into the waters of the Great Lakes basin may be said to date practically from that year. This was only twenty-five years ago, and the wonderful increase of carp since that time is in many ways comparable to that of the English sparrow in this country.

The distribution of carp in 1880 did not take place until late in the year—in November for the most part—and it is not likely that many reached the public waters that fall. Many of them surely did so the following season, however, to say nothing of those that were planted

there directly by the government and state commissions. There was at this time a fever of enthusiasm for carp culture throughout all parts of the United States. From the time of the proposed introduction the Fish Commission had published many papers, including a number of translations of German articles, giving much information on the habits of the carp and its desirable qualities, and explicit directions as to the methods in vogue in raising carp in Germany, where this industry is most important. The newspapers took the matter up and were loud in its praises, but neglected to give so large a share of attention to the practical side of the question—to the care and attention the fish should have in order to make the venture a success. Most men are interested at once when they think there is a chance of getting something for nothing, and here seemed to be an opportunity to have a perpetual supply of fresh fish for anyone who had land with any kind of a mud hole on it that would hold a few bucketfuls of water. Accordingly applications for carp piled in, and were filled as soon as possible. As a result of ignorance and neglect, a large proportion of these fish or their offspring were soon undoubtedly in the public waters—largely from the breaking of dams of improperly constructed ponds, and two years later (in 1883) came reports of their being taken in considerable numbers by fishermen in the rivers and lakes.

Besides the stocking of the public waters which occurred accidentally, many fish were also purposely planted in them. In 1881 the Ohio State Fish Commission put 40 carp into the Maumee River (Ohio Fish Commission Report, 1882, p. 1435), and in May of the same year some were planted in Ten Mile Creek. These were $2\frac{1}{2}$ inches long when liberated, and it is reported that in the following September and October a number were caught which would weigh $4\frac{1}{2}$ to 5 pounds, while one had a weight of 8 pounds. In the same report we read that 12 carp were given to Mr. Charles Carpenter, of Kelleys Island, which is in the very midst of the breeding grounds of the white-fish, and 17 to Mr. Edward Lockwood, on the (Catawba) Peninsula. Both of these lots doubtless contributed sooner or later to stock the lake. Indeed, one of the first lots of carp sent out from Washington was in November, 1879, to Mr. Lewis Leppelman, Fremont, Ohio (Smiley, 1886, p. 792), which is on the Sandusky River, and probably there is no place in the United States to-day where carp are much more abundant than in the waters of Sandusky River and Bay. In July, 1883, however, Mr. Leppelman thought he still had all his fish, so they could not have contributed to the first stocking of the river and lake.

One of the earliest records I find of the taking of carp in Lake Erie, where they are now so abundant, is given in a compilation by Mr. C. W. Smiley (1886, p. 738) among the statements of those who received carp of the Fish Commission. This is the statement of J. C. Sterling, of Monroe, Mich., December 10, 1883, that one of the

Monroe fishermen found in his catch of white-fish the previous week a fine specimen of German carp which weighed $3\frac{3}{4}$ pounds. The pound from which the fish was taken was in Lake Erie, about three-fourths of a mile out from the mouth of Raisin River. I was unable to learn from the fishermen of this region the exact year when they began to catch carp, but all agreed that it was "in the early eighties." I was told that when the first carp were taken no one about the fish houses knew what they were, and they were kept on exhibition in tubs as curiosities. It is needless to say that they are no curiosity there now, when hundreds of tons are shipped from a single place in the course of a year.

About this same time carp began to be taken by the fishermen in the waters of the Mississippi River and its tributaries. Early in July, 1883, a fisherman at Naples, Ill., on the Illinois River, caught a mirror carp weighing 5 pounds. At Pekin a mirror carp was taken which weighed 6 pounds, and at Meredosia, also on the Illinois River, another, with a weight of 8 pounds (Illinois Fish Commission Report for 1883, pp. 10-12). Carp which had escaped from ponds were also taken at or near Hannibal, on the Mississippi, and young carp were taken at Quincy. Their numbers have increased to a remarkable extent, until now the carp forms the most important fishery product of Illinois.

The Great Lakes are, on the whole, not well suited to carp. Their sandy or rocky bottoms near shore are hard and wave beaten, and support at the best a very scanty vegetation, while they slope off so quickly to a considerable depth that the sun has little chance to raise the temperature of the shallow water to that degree of warmth most favorable for these fish. The western end of Lake Erie and Lake St. Clair, especially at its upper end, on the broad delta formed by the St. Clair River and known as the St. Clair Flats, are exceptions. In the latter place the shallow bays often possess soft, muddy bottoms, and are filled with animal and plant life similar to that found in the smaller inland lakes. These conditions suit the carp well, and it is found there in great abundance. Even better are the conditions in Lake Erie, for the whole upper end of the lake is of inconsiderable depth, while into it open rivers and bays with hundreds of square miles of flat, muddy, reed-grown marshes, which furnish ideal feeding and breeding grounds for a fish like the carp. It is probable that the fish breed, for the most part at least, in the marshes; but they are often fully as abundant in the lake itself. Just what relation they have to the two places—to the marshes and to the open lake—has not been definitely determined, but the probability of their migration from one to the other, with possibly more or less regularity, will be discussed later.

The most extensive marshes connecting with Lake Erie are those of Sandusky Bay and Sandusky River, which opens into it. the marshes

along the Portage River above Port Clinton, at Monroe, Mich., and at places along the north shore. These last I have never had opportunity to visit. Marshes of less extent occur at Erie, Pa., and at other places along the south shore.

It must not be supposed from what has been said that the carp are by any means limited to the places mentioned in Lake Erie and Lake St. Clair and in the waters of the Mississippi River and its tributaries. As a matter of fact they are usually present in numbers in any of the inland lakes and streams of the region which are suitable for them, and especially near the mouths of many of the rivers emptying into the Great Lakes, which usually have more or less extensive marshes for some distance back. This is true of nearly all the streams which open into the lower end of Lake Huron, Lake St. Clair, and Lake Erie, and into the St. Clair and Detroit rivers, connecting them. It is due to a slight tilting of the earth's crust to the southeast, which has caused the waters to flood the lower courses of the streams and produce what are known as "drowned channels." The marshes along the western side of Michigan are probably due for the most part to a simpler cause. There the sand, which is thrown up by the waves and has been blown up into immense dunes, tends to choke up the mouths of the streams entering Lake Michigan, causing them to flood the country many miles back. Such marshes are found along the Kalamazoo, Black, and Grand rivers, and at Muskegon and other places along the lake, in all of which carp are plentiful.

That the extensive carp fisheries are at present confined to so few localities results from a number of causes, among which is not so much the relative abundance of the fish as the ease with which it may be taken. The shallow shores of Lake Erie and the equally shallow bays of the St. Clair flats afford excellent places for hauling a seine—an operation which is often attended with great difficulty or is well nigh impossible in the marshes, where the bottom is soft and the water grown with weeds. Local laws also, in some places, interfere with the seining of carp.

HABITS AND SPECIAL SENSES OF THE CARP.

Observing wild carp under natural conditions requires much care and a great deal of patience. Under favorable circumstances, when not disturbed or alarmed, they may often be seen swimming lazily about among the weeds in shallow water, frequently with the dorsal fin projecting above the surface. Their mouths are constantly in motion as they breathe, taking in water and expelling it through the gills, and at the same time working about in the mud or over the surfaces of the water plants for food. The resemblance of their mouths to that of the sucker is at such times especially apparent. In spite of the appearance of taking life so easily, they have nevertheless the

ability for quick and powerful movement, for, let anything give the fish the least fright, there is a twirl, a splash, and it is gone. It is, in fact, a strong and rapid swimmer when it puts forth the effort. One who has occasion to search for carp comes to be able to recognize them almost without fail just by the way they make this sudden break and dash away, even if the water is so roily—as is often the case—that the fish can not be seen at all. If the water is more than a foot or so in depth, there is usually not a splash, although there is an audible sound, a sort of dull thud; the water boils up where the fish started with the first strong lash of its tail, and a disturbance of the water due to the rapid passage of the fleeing fish underneath shows the course as it dashes away. This it usually does in an almost straight line—that is, it does not zigzag about. If the water is clear, a glimpse of the fish may be caught; or, if among rushes or cat-tail flags, the movement of these indicates the line of retreat. If a considerable school of large carp is startled, and they go off in this way through the rushes, the whole surrounding growth will wave and rattle as if a sudden and erratic wind had struck it, the reeds twisting and bending in all directions at once. There are other fish, such as the fresh-water dog-fish (*Amia calva*) and some of the bass, which one will sometimes start up singly here and there among the rushes, and which will dart suddenly away; but anyone who ever chances to startle a school of carp in this way will have no trouble guessing the authors, if, indeed, it occurs to him to attribute so much commotion to fish at all.

This refers to carp in the open. In ponds they become easily tamed, learn to come to a certain spot to be fed, and, it is said, will even take food from the hand. This tameness in small ponds probably depends not only upon the familiarity the fish come to have with the surroundings and with people, but as well upon the fact that they are better fed and the struggle for existence is greatly reduced—their common enemies are absent, so that they get less exercise and tend to become more sluggish in temperament. To prevent this, it is the custom of European fish culturists to introduce into their ponds certain predaceous fish, such as pike, which keep the carp active and in good condition.

That carp are wary is well known to fishermen, who speak of them as “wise,” “knowing,” and “cunning.” For this reason their capture is difficult. They usually avoid the ordinary form of set net, so that comparatively few are taken in fykes, traps, or pounds. Seines, once around them, are difficult to evade, and it is in this way that they are taken for the most part. But if a seine becomes torn or does not drag closely on the bottom they are quick to find the opening, while large numbers often escape by jumping out of water and clearing the cork line. Day speaks of this characteristic of the carp in his work on the

Fishes of Great Britain and Ireland (1880-1884, p. 160). To use his words:

The fisherman finds this fish an adept at escaping from nets, by burrowing below it, or springing over the corks, . . . So difficult is it to net that . . . one can well understand the Norfolk pen-men regarding it with mysterious awe, how its entrances and its exits into pieces of water puzzle them, and how, as Lubbock remarks, they consider it as something more than a fish, and look upon it as what the Scotch term "no cannie."

Although I have spoken above of the carp's habit of ordinarily swimming about lazily and quietly, this is by no means always the case, for these fish often produce a considerable disturbance by their splashing. This is when they are feeding in shallow water, and will be discussed more fully when we come to consider the feeding habits. They also splash about considerably at the breeding time.

Carp exhibit a marked tendency to go about in schools. In regions where they are abundant, it is usual to find either a large number in a given locality, or else none at all. That these schools are frequently of great size is apparent from the fact that several tons of carp are often taken at a single seine-haul along the shore of the open lake, which is rather more conclusive evidence than is afforded when they are taken in a bay or other partially inclosed place.

Moderately warm, shallow waters with abundance of aquatic vegetation, and deeper places to which the fish can retreat, are the most favorable conditions for carp, and it is in such places that they multiply fastest and obtain their most rapid growth. In the hilly eastern part of the United States localities of this kind are relatively scarce, but the rivers and lakes of the Southern and Middle States, with their extensive bayous and marshes, come very close to the ideal conditions. This suitability is abundantly evidenced by the rapidity with which carp have taken possession of them, and have become in them, it might almost be said, the dominant piscine type. Nevertheless they are by no means confined to these waters which meet their requirements to the best advantage, but seem to be able to adapt themselves to a variety of conditions, though with less success. Thus we find them invading to a certain extent the colder and deeper waters of the Great Lakes, though a few fathoms is a great depth for them, and I have no evidence to show that they go to any extent into the deeper waters. They will live in small ponds fed by springs, where the temperature of the water always remains very low, but in such places their growth is slow and they are by no means so prolific as in warmer waters. On the other hand, they may sometimes be found living in mudholes, where it would not seem that they could obtain enough food for existence and where the temperature must at times in summer become comparatively high. They will live, and apparently do well, in waters that are strongly mineral. I saw, for example, a carp pond in northern Ohio

fed by an artesian well so heavily charged with sulphur that what appeared to be free sulphur was deposited in the wooden trough which conducted the water from the pipe to the pond. It is said that they even occur in abundance in the brackish or semibrackish waters of the Atlantic coastal region (Townsend, in "Discussion on Carp," Transactions American Fisheries Society for 1901, p. 117); and Day (1880-1884, p. 162) states that "a considerable number are taken in the Black Sea and Caspian; and Nordmann remarks upon their presence in the salt lakes of New Russia."

SIGHT.

Although carp work about in muddy, roily water, the roiliness being due largely to their method of feeding, they have, nevertheless, a quick sight, which serves them well when the water is clear. As will be discussed more fully under the subject of hearing, many actions which have been attributed to that sense are in reality dependent upon sight. Not only do they take fright easily at anything which moves, but there can be no doubt that they are able to recognize unusual stationary objects as well. I have often stood quietly for long times where the water was clear and carp were feeding on all sides of me only a short distance away. But when a fish came in my direction, it seldom approached closer than seven or eight feet, and usually not so close, before it would take fright and dash suddenly off. On the other hand, I have sometimes stood in roily water when they would actually bump into my legs before they would turn with a splash and dart away. At one time I built a scaffold some seven feet high above water in order to be able to overlook a wider circle of marsh. It was on the edge of a large spawning ground of black bass, and although a bass which was guarding a nest not far from the base of the scaffold soon became accustomed to the unusual structure and resumed his domestic duties, few carp came in sight, in spite of the fact that I sometimes remained quietly there for an hour and more at a time. When they came within a circle which would be traced by a line at an angle of approximately 45° from my position to the water, they apparently became frightened, and left suddenly.

In attempting to study the behavior of the fish at night, I at another time employed a powerful acetylene searchlight, such as is manufactured for use on launches. But this seemed to frighten them, even when 4 or 5 rods away. As the beam of light was swept around to different points I could hear the carp dash away through the rushes, and could sometimes see the disturbance they caused in the water, but in no case was I able to get close enough to see the fish themselves. Common experience in fishing at night with a "jack" shows that many kinds of fish are not so frightened by a sudden strong light.

That sight plays an important part in the feeding of carp may

readily be seen by the way they sometimes immediately take food thrown into the water before it has a chance to settle to the bottom. I have made no experiments to test accurately the sense of sight in carp.

HEARING.

It has always been a widespread opinion among carp culturists and fishermen that these fish are quick to detect and respond to ordinary sounds, such, for example, as the human voice. It is well known that pond fish regularly fed at a particular place soon learn to congregate at that place to receive their food. Many such instances have been recorded not only for carp, but for gold-fish, trout, and other species. As an illustration of the popular belief, which was apparently as prevalent in this country as in Europe, I may quote the statement of Mr. S. W. Coffin, given by Smiley (1886, p. 696):

The sound of my voice is sufficient to bring them to the surface of the water, and a whistle causes them to come for food. For this they scamper through the water like so many pigs. They disappear as suddenly at the voice of a stranger.

Seeley (1886, p. 98) says:

The hearing of the carp is excellent, and there are many examples of their answering a call; and it moves by hearing even when it cannot see. It makes an audible sound in eating and in swallowing air.

Fishermen, both here and abroad, are very careful to make as little noise as possible as they set their nets around a school of carp in the open or prepare to seine them from a pond; but when the net is set and it is desired to drive the fish into it they splash the water and shout to make all the noise they can.

Parker (1903) has recently investigated this sense in a few fishes and has given a general discussion of the subject. Since then Bigelow (1904) has done the same for the gold-fish; and since this last is such a near relative of the carp, we may be reasonably certain that the conditions in the two species are much the same. The experiments of these authors show without doubt that certain fishes, including the gold-fish, and so we are safe in assuming also the carp, are capable of hearing sounds produced in the water, or which are transmitted directly to the water, such as striking the side of a boat with an oar. I have had opportunity to see evidence of this in the field myself. By paddling quietly and carefully I have been able to work my boat into an open area in a pond where carp were present in numbers without disturbing a fish, when a sharp blow against the rail of the boat with the paddle would send them scurrying into the rushes in all directions. In this case, however, other vibrations besides sound waves are transmitted to the water which the fish might perceive by the sense of touch, so that such an experiment could not be considered as conclusive evidence that the fish heard the sound. This complication was obviated in the experiments of the authors mentioned above by the

use of an electric tuning fork giving a certain number of vibrations per second, which was placed against a board end of the aquarium in which the fish were being tested.

On the other hand, most fish "appear to be unaffected by loud talking or other like noises originating in the air" (Parker, 1903, p. 45), due undoubtedly to the fact that the ordinary sound waves produced in the air are transmitted to the water to a very slight extent at most. Several years earlier Kreidl (1896) had performed certain experiments on trout in the fish basins of the Benedictine Monastery at Krems, Austria, where the fish were called up to be fed at the ringing of a bell. He found that the fish appeared just the same if a person went to the customary place without ringing the bell, and that no amount of bell ringing would bring them if the person remained out of sight. On this account Kreidl concluded that fish could not hear at all. That sight is the important factor in the assembling of gold-fish to be fed was suggested by Seeley (1886) some ten years before, though he credited them with the ability to hear as well. He says (p. 112):

Their sense of sound is sufficiently acute to obey a familiar call. The Chinese are said to assemble them in ponds at feeding-time in this way; but in ponds where visitors feed them in Europe they presumably detect the newcomer by sight; for we have noticed that a gathering never fails to greet visitors on their appearance at public gardens in which these fishes are exhibited.

From all this it appears that while fishermen, when desiring not to frighten the fish, need to be careful not to make disturbances which are transmitted directly to the water, such as splashing, or jarring a boat or similar object partially submerged, they need have little fear of talking; while, conversely, shouting probably has as little effect in helping to drive the fish, when that is the result desired. This fact will probably be received with satisfaction by those anglers who believed it necessary, but found it onerous, to maintain a sphinxlike silence while trying to outwit their finny prey.

TASTE AND SMELL.

As a matter of convenience these senses will be considered together. Of the two in fishes the former is much the better understood. Herrick (1903) has recently made an important contribution to the subject, besides giving an excellent review of the literature. It has long been known that carp have sense organs, known as "terminal buds," over the whole surface of the body and on the barbels, similar to those which occur abundantly in the mouth, and to which the sense of taste has rightly been assigned. Direct physiological experiments have not been made on carp, but from his experiments on a large series of other fishes Herrick concludes (p. 266) that—

It may be regarded as established that fishes which possess terminal buds in the outer skin taste by means of these organs and habitually find their food by their means, while fishes which lack these organs in the skin have the sense of taste confined to the mouth.

Terminal buds, or taste-buds, outside the mouth are best developed in bottom-feeding forms and those which, like the carp, burrow into the mud for their food. They probably enable a carp to determine the presence of food material in the mud without actually having to take the mud into the mouth to test it.

What part the sense of smell plays is not so well established, though from the experiments that have been made on other fishes it would appear to be of minor importance and to be of little value in a directive way in the finding of food. In many fishes, however, it appears to enable them to detect the presence of food when it is in the immediate vicinity.

The tactile sense is well developed. How far carp can detect slight movements of the water, a faculty attributed by Parker (1903) to the lateral line, has not been determined.

MIGRATIONS.

The word migration is not used here in the strict sense of a regular and stated movement from one place to another, such as occurs in the salmon, shad, suckers, and many other species that ascend rivers and streams to spawn. The only habit of the carp which can be compared to this is their retreat to deeper water with cold weather and their return to shallower water with the coming of spring. Their movements at other seasons appear to be irregular and probably depend upon local and variable conditions. In ponds and other small bodies of water such migrations are necessarily limited, but may be much more extended and noticeable in large bodies of water such as the Great Lakes.

Some attempt was made to study this question in Lake Erie and the adjacent waters by liberating tagged fish and distributing a circular among the fishermen and fish dealers of the region, asking for the records of any of these fish that might be recaptured. A small copper tag bearing a number was attached, usually to the strong spine of the dorsal fin, by a piece of copper wire, though in a few cases the wire was passed through the basal lobe of one of the pectoral fins. This work was attempted only on a small scale at first, and later opportunity did not offer for giving it a more effective trial. Moreover, the method in which the carp are handled by the fishermen and in the wholesale houses made it very unlikely that the small tags would be noticed before the fish reached the retail dealers in far away cities, when it would be too late to get the desired data, even if the tags were returned. As it was, only about one hundred individuals were tagged and liberated, mostly in the vicinity of Port Clinton and Sandusky, and none of these was ever heard from again. As a consequence, direct observation and the results and testimony of the fishermen had to be relied upon for what information on this subject they

would give, and as the evidence gathered in this way was rather meager the question is still far from settled. Some of the observations are of much interest, however, and may serve to throw a little light on the subject.

A large proportion of the carp shipped from northwestern Ohio and southeastern Michigan are taken directly from Lake Erie. Many fishermen are engaged in the business, and they, for practical purposes, have had to learn much about the habits of the fish which furnishes them their livelihood. They go to the fishing grounds usually in open sail boats, returning to market when they have secured a good haul of fish. This means only a day's, or possibly two days', fishing when the carp are "on," but under unfavorable conditions the boats are often gone a week or more. The fish are taken for the most part by means of seines in shallow waters along shores. The methods of seining will be described more fully later (p. 611).

It is not surprising, in a body of water the size of Lake Erie, that storms should affect very largely, in fact we might almost say control entirely, the abundance of carp along the shore. According to the government chart, there is nowhere in the upper end of the lake more than six fathoms of water, while along the southern side water less than three fathoms deep extends to a distance of two to five miles off shore. Strong northwesterly winds are not infrequent during the summer months, and in the winter the principal storms are from the north and northeast. It does not take very high winds to stir such shallow waters to their depths, as is shown by the fact that even in moderate storms the water is made roily to a long distance off shore. At such times the carp apparently go out to the deeper waters, and the fisherman say they do not come in again until a day or two after the storm. Unfortunately the only data we have for determining the extent and character of these movements are the occurrences in the shallow shore water; we have little or no data for telling where the fish go when they leave. Pound nets in the vicinity of Niagara Reef, which is seven miles from the nearest land, and which were kept in operation all summer by a Port Clinton firm, did not help to throw any light on this question, since few carp were taken in them at any time. It is possible that during storms some of the carp leave the lake and run up the bays and rivers, and I am not convinced that such is not the case, at least with easterly storms, which raise the water level very appreciably at the western end of the lake. This produces a backward current up the bays and rivers, and evidence will be brought forward to show that carp run up the rivers with this back set. But storms from the north do not have this effect, while westerly winds lower the water rather than raise it. So while I think it not unlikely that many of the carp in the lake may enter the bays and rivers when there is an easterly wind, it seems that if this were

generally true with all storms, whatever their direction, it would surely be known to the fishermen, who utilize this movement of the fish in the river for their capture, as will be explained later.

As mentioned above, the water level at the upper end of Lake Erie is very variable. The long axis of the lake lies nearly west-southwest and east-northeast, so that both westerly and easterly winds have a great influence in piling the water at one end or the other. The prevailing winds of summer are southwesterly to westerly, so that the level is almost constantly changing. This gives a great resemblance to tides, except that the changes are, of course, much less regular, and generally of less amplitude. A strong southwest wind, however, blowing steadily for a day or two, will lower the general water level in Sandusky Bay, for instance, a foot or more, while a long-continued storm may result in an even greater change of the level. As soon as the wind ceases, or shifts around to the opposite direction, as is usually the case in our cyclonic storms, the reverse current sets in, affecting the water for miles up the Sandusky and Portage rivers.

Just how far this variation of the water level and the consequent reversion of flow of the rivers influence the movements of the carp I am unable to say. This much, however, is certain. A fall of a foot or even less in the general water level means the laying bare of great expanses of marsh land, and the carp which were feeding over this area have to seek deeper water as that on the flats gradually becomes shallower. In this way they work into the smaller streams, and so into the larger creeks, and from these into the river. It is at such times that they are taken in large numbers in a seine which has previously been stretched across the mouth of the creek, as will be described more fully in connection with the methods of fishing (p. 613). The fish appear to be quick to appreciate the lowering of the water, for they begin to run out very soon after it has begun to fall. Conversely, they run up again and spread out over the marshes as the water rises.

This movement, which seems to depend upon the gradual lowering of the water in the shallow places, is distinctly different in nature from the ordinary reaction of most fishes to a current of water. As is well known, most fishes, when placed in running water, immediately react by turning head-up into the current.^a That this is true of young carp, I have ascertained by experimentation. It may also be the explanation of the crowding of these fish around the inlet when fresh water is being pumped into a pond, a phenomenon which will be described more fully in the discussion of their reaction to fresh water (p. 560). It is equally true that most fish become uneasy as the water in a vessel or other container is gradually lowered without producing a definite strong current. It is probably this "uneasiness" which causes the fish to leave the marshes as described above.

^a For a discussion of the orientation of fish to running water see a recent paper by Lyon (1904).

As to the movements of the fish in the wintertime, when the rivers and bays are frozen over, I have no information. That they are in the deeper parts there is no doubt, and it seems likely from what I can learn from the fishermen that they must move about more or less even during the coldest weather. They are occasionally taken in numbers at this season, I am told, by means of a seine hauled under the ice.

It will be seen from what has been given above that, although they apparently do not have any regular and definite migrations, carp do make considerable movements dependent upon the conditions under which they live. It was at one time thought there might be some evidence to show that in Lake Erie the carp were coming to make a rather regular migration into the deeper parts of the lake with the approach of cold weather. The lake grows deeper to the eastward, and this would mean a general movement to the eastward in the fall and to the westward again in the spring. This habit in time might become established into a definite migration. But though the fish do undoubtedly seek deeper water in the winter, they probably go only far enough to escape freezing and the effects of storms. So long as they both feed and spawn in shallow water there is no other need for a migratory habit, unless perhaps the overpopulating of the more favorable waters may force some of the fish to seek new grounds. Reports of large schools of carp at times seen toward the eastern end of the lake seemed to lend some support to this view. Thus I was told by Mr. Crangle, a fisherman in Cleveland, that some time in July, 1901, large schools of carp were seen in the open lake. In near shore were small fish, while farther out were schools of large ones, which were noticeable from their swimming about with their dorsal fins out of water. Mr. Crangle says this was the first time carp had been seen in this part of the lake in such numbers; and he was certain of the identification, because his tug was run right in among them. Prince (1897) maintains that the carp has an inherent nomadic tendency, and thinks it is owing to this, in large part, that it has gained such a wide distribution. He says (p. 33):

German carp are nomadic in their habits, and wander apparently aimlessly into all accessible waters, hence if introduced into any streams or ponds adjacent to and connected with others, these fish will rapidly spread over the whole system. Salmon, trout, white-fish, pickerel or doré, indeed all our native fish are more local in their wanderings and as a rule have definite courses of migration, and confine themselves within recognized limits. The German carp has no such defined movements or habitat, thus Lake Erie, the St. Clair waters of western Ontario, Lake Huron and other Canadian areas are being overrun by these fish, which have wandered from the more or less remote localities in United States territory where they were originally planted. Like undesirable weeds they spread everywhere and it is practically impossible to limit their progress or to effect their extirpation.

REACTION OF CARP IN PONDS TO INFLOWING FRESH WATER.

This reaction, which is very curious and marked, I am uncertain whether to consider a reaction to the current caused by the inflowing water or a response to the volume of fresh water being added to that which has been standing in the pond. Hessel (1881, p. 879) says:

The inflow of water into the pond should never be allowed to be direct; as, for instance, a brook falling into it. This often causes the water to rise at an inopportune time, carrying into the pond other fishes, especially the rapacious pike. *The carp also has the disposition to swim toward the inflowing water, by which means it is drawn away from its proper feeding-places.*^a

This matter was first brought to my attention in a practical way by Mr. Thomas Hurrell, who owns a carp pond near Port Clinton, Ohio. This pond covers an area of some 20 acres, or more, of marsh land beside the Portage River. A deep cut was made along the riverside and embankments thrown up on three sides so that it is possible to keep the water level two or three feet above that of the river, the fourth side of the pond being formed by the natural slope of the land. The water is maintained at a nearly constant level by pumping in fresh water, as necessary, from a dredge-cut just outside the embankment which leads from the river. The water is really elevated by means of an endless-chain elevator. This is shown in figure 2, plate III, while figure 1, plate III, shows the chute which empties into the pond. At this place the water in the pond is some 8 to 10 feet deep, and directly from it leads the deep ditch along the riverside, while shallower ditches lead off into other parts of the pond. (See figure, p. 628.) Mr. Hurrell said that scarcely has he started the elevator when the fish begin to come from all parts of the pond and to congregate in the deep area where the fresh water pours in. His account of their quick response seemed almost incredible, and I expressed a desire to see the thing myself; at which Mr. Hurrell kindly started the gasoline engine operating the elevator, and at once a good stream of fresh water began to be poured into the pond. I was subsequently fortunate enough to witness the phenomena I am about to describe on several different occasions. The following account is taken with little change from my notes of one time:

At the time of which I am speaking, a number of carp could be seen swimming about in the vicinity of the pumping house with their backs out of water. Mr. Hurrell attributed this to the fact that he had recently been pumping, and that the fish had not all dispersed as yet. He now started the engine again, and within five minutes the carp began to congregate in numbers in that vicinity, and they could be seen coming far down the large ditch, as many of them swam with their dorsal fins above the surface. The water near the inflow was soon full of them—it seemed as if there must be a number of tons of fish right

^aThe italics are mine.

there. They worked continually up toward the chute, where the water poured in, heading for the most part in that direction, but turning and twisting slowly about. They became so numerous after a time that the upper ones seemed almost forced out of the water, and many were turned over on their sides at the surface. Figure 4, plate III, shows a nearer view of the writhing mass of fish, all struggling to get nearer to the source of incoming water, though their movements appear rather slow and deliberate. Here it will be noticed that some of the fish are turned on their sides, and by the exposed backs it can be seen that they are nearly all headed in the same direction—to the right in the photograph. It was impossible to estimate the number of fish; there was no way of telling, in fact, whether they were mostly at the surface or whether they were as numerous deep into the water. I found, however, that at a distance of 20 to 30 feet away, where few backs were to be seen at the surface, an oar could not be put down into the water without hitting fish. Before long those nearest the chute began jumping out of water, some jumping to a height of nearly 2 feet into the air. Others made a jump and swam up the chute against the current as salmon leap a waterfall. Most were able to get up here but a short distance, while others worked up the whole length of the chute, some 6 or 8 feet, to the elevator itself.

From the actions of the fish in the vicinity of the inflow it seems as though they must be reacting to the current. There is no direct evidence that the response is anywhere to the fresh water and not to the current, as it is evident that to any part of the pond where the fresh water comes so as to influence the fish there must necessarily be some current. The part that seems incredible is that it should so soon effect remote parts of the pond with sufficient strength to produce a positive rheotactic response on the part of the fish. It will be noted, furthermore, that if this is the correct explanation the response appears to be just the opposite of what has been given above for fish in the marshes when there is a change in the general water level of the river. There the fish ran with the current, spreading out over the feeding grounds; here they come against the current as far as they are able to come, and crowd about the inflow. What may determine the difference in the nature of the responses in the two cases I am unable to say.

HIBERNATION.

Most observers agree that during the cold months in the temperate regions carp seek the deeper holes in pond or lake, where they pass the season in a semitorpid condition. It is said that they assemble in circular groups with their heads together and pointed somewhat downward towards the mud. During this time they take no food, though they are said to decrease but little, if at all, in weight. I know of no

statement as to whether the respiratory movements are suspended, and I have myself had no opportunity to observe carp in this condition. When I visited Lake Erie in November, 1901, some carp at least were still moving about, as they were taken in small numbers daily in the pounds and gill nets set for white-fish. This in spite of the fact that the weather was very cold, with frequent snow squalls, though the lake had not yet begun to freeze. Examination of the stomachs of these fish showed, too, that they had been feeding, though in no case was there much food in the alimentary tract. This observation agrees with the statement of Brakeley (1889), who says that instead of hibernating with the nose in the mud for several months, as they do in Europe, in this country they do so only for a short time, if at all.

VITALITY.

Many instances have been reported to show the extent to which carp can resist cold. I can not do better than to quote a case reported by Smiley (1886, p. 676):

On the morning of January 4, 1884, 2,100 German carp were forwarded from Washington, by express, to Birmingham, Ala. Mr. F. L. Donnelly, a messenger of the Commission, proceeded by the same train to watch them on their passage and to take charge of them upon their arrival at Birmingham. The fish had been placed in the usual 4-quart tin pails, and packed in crates of 16 pails each. Each pail contained 15 carp.

Mr. Donnelly and the carp arrived at Birmingham at 1.30 a. m., January 6. The packages were left in the office of the Southern Express Company through the remainder of that night, but placed within 10 feet of the stove in order to prevent the water freezing. The thermometer indicated $+4^{\circ}$ F. at the time of arrival. At 8 o'clock on the morning of the 6th Mr. Donnelly examined the condition of the fish, and in his official report dated January 14, says:

"I was greatly surprised to find every drop of water in the buckets frozen into solid ice, and all the fish apparently dead; but upon close examination of their eyes, I thought perhaps a great many of them were still alive, though frozen solid in the ice."

Mr. Donnelly thereupon courageously undertook to see if any of the fish could be saved. He procured the necessary laborers, four large tubs, and a supply of water. He then broke the ice from the small pails, transferring such as contained carp to the water. He states that "in this manner a great number of fish were soon freed from their confinement, and by constant working with them during the entire day we were able to save 1,300 fish." Although the thermometer continued to remain in the vicinity of zero, by careful management he succeeded in keeping the 1,300 fish alive until the 8th and 9th, when they were distributed to the applicants throughout the State.

The saving of 1,300 carp out of a lot of 2,100, under such circumstances, may be considered a very remarkable achievement.

Having prepared the foregoing statement from Mr. Donnelly's report, I sent a copy of it to Mr. L. H. Black, route agent, Southern Express Company, Montgomery, Ala., asking how far he knew the statements to be true. Under date of January 25, 1884, he wrote me in reply as follows:

"As route agent of the Southern Express Company, my duties call me to Birmingham. I saw the carp first on the morning after their arrival at Birmingham, and frequently during the day while Mr. Donnelly was at work with them. My opinion

is that this statement is correct in every particular. I give it from what I saw myself, and from information Mr. Donnelly gave me during the day while he was working with the fish."

Smiley gives another instance (p. 698). This is the statement of Dr. George Wigg, Clay Center, Clay County, Kans., and is as follows:

I have a German carp in my office that has been frozen stiff on 16 different occasions in one month, and yet each time resuscitation has been produced after the lapse of six hours.

Although known as cold-blooded animals, the internal temperature of fishes is normally somewhat higher than that of the water in which they are living. According to Knauthe (1896) the amount of this difference depends upon the condition of nourishment, and varies in the different races of carp. In the winter, when no nourishment is taken and the vital processes are mostly suspended, the temperature of the body becomes the same as that of the surrounding water, and Knauthe states that the crowding together at the bottom of such fish as the carp, tench, and barbel does not help to keep their temperature up, as is maintained by some authors.

The hardiness of carp in enduring low temperatures for a long time without serious result is sometimes utilized in shipping them, by placing ice in the water to keep the temperature down. The normal activities are then much reduced, the respiration is retarded, and the fish can consequently stand a much longer sojourn in a small amount of water than would be possible at ordinary temperatures. I am told that the fish packed in ice even at points in Illinois and northern Ohio are sometimes still alive when they reach New York, in spite of the fact that they are sent by freight. Townsend (1902 *b*, p. 677) says those in the top layers will live two or three days; those below die sooner. In this case, of course, they are out of water entirely, though the gills are prevented from drying and the fish are kept moist by the gradual melting of the ice.

Like many other hardy fish, carp can be kept alive out of water for considerable periods at ordinary temperatures if they are kept moist, and they are often transported for short distances by packing them in wet moss. In Germany it is said to be a common practice at such times to place in the mouth of the fish a piece of bread or cake soaked in brandy. The statement is commonly quoted, especially in European works dealing with the subject, that carp are sometimes packed in moss with the head protruding and are kept in this condition for weeks or even months (!), being nourished in the meantime by placing food in the mouth. As an example of what is often stated, the following may be quoted from Day (1880-1884, p. 160):

Pennant observes upon the following experiment having been twice made, of placing a carp in a net well wrapped up in wet moss, the mouth only remaining out, and then hung up in a cellar or some cool place, the fish being frequently fed with bread and milk, and often plunged into water. Thus treated it has been known to live above a fortnight, and grow very fat as well as lose its muddy taste.

Whatever may be the truth as to the above, it is certainly a fact that these fish can withstand much in the way of adverse conditions, and can live for a considerable period out of water so long as the gills are kept moist. When it is desired to transport fish from where they are caught it is usual for the fishermen merely to load them into the bottom of a boat when the distance is not too great. For longer distances by water they are usually towed in a live-car.

When the United States Fish Commission was distributing many thousands of young carp every year it became a matter of great importance to have some practical method that would be economical as well as efficient. The original plan was to send a few fish in a large milk can full of water, but this practice was expensive and unsatisfactory. Later it was found that the fish could be shipped long distances, requiring several days or a week for the journey, merely by putting them in small pails with only a little water. The usual method was to use 4 or 6 quart tin pails, in which were placed 15 to 20 young fish 2 to 3 inches long, with little more than enough water to cover them (see McDonald, 1882, and later reports of the Commissioner). This small amount of water is kept well aerated by the jostling of the pails in transportation and the movements of the fish. In fact, it usually becomes foamy, on account of the slime secreted by the fish. I have myself used this method with success in shipping young carp from Port Clinton, Ohio, to Ann Arbor, Mich., the fish being about two days on the way.

Although carp will live so long out of water if the gills are moist, or in a small amount of water well aerated, they succumb much more quickly to foul water—that is, to water not well aerated, and consequently charged with carbonic acid or unoxidized organic matter. Under such conditions they may usually be seen swimming about with their mouths at the surface, a circumstance that is always to be looked upon with suspicion by the owner of a carp pond, as it usually means that the fish will die unless the conditions are quickly improved. Carp are apt to do the same thing when the temperature of the water becomes too high. Of course this action must be distinguished from the normal feeding of the fish at the surface.

FEEDING HABITS AND FOOD.

Carp are frequently stated to be “essentially vegetable feeders.” It seems to me better to say that they are omnivorous, for I know of no food substance which a carp can get into its mouth that it will not eat. Since it can not be considered in the ordinary sense a predacious fish, however, the animal matter which it can ordinarily obtain is limited largely to insect larvæ, small crustacea and mollusca, and other similar small organisms, so that the bulk of its food is undoubtedly in most cases vegetable. Carp are often compared to pigs in their feed-

ing, and the simile is not bad, for much of their food is obtained by rooting about in the mud. In soft muddy or marly bottoms one will often see numerous little pits and holes a few inches, or often more, in diameter, showing where the fish have been at work. In most of its feeding the carp works slowly and rather quietly, though persistently; but the rooting in the mud they often undertake in a more vigorous manner, twisting and splashing, and tugging at the roots of water plants. It is this that makes the water so roily, and anyone familiar with their habits can tell at once the presence of carp when they are feeding in this manner simply by the appearance of the water. Moreover, the freshly dug up stems and leaves of cat-tails, sweet flag, wild celery, and other water plants are often to be seen floating about, furnishing further evidence of the destructive work going on below. The extent to which the character of the aquatic vegetation is changed in this way will be discussed later, when we come to consider the economic aspects of the question. The fish probably dig up these plants mostly for the tender shoots and rootlets, but they undoubtedly obtain many smaller organisms from the mud at the same time. The barbels at the sides of the mouth, which are well supplied with taste buds, are probably of much assistance in helping to ascertain the presence of food particles in the mud. I have not been able to observe the process in natural surroundings, but judging from the actions of small carp kept in an aquarium, I should say that much of the mud is sucked into the mouth and further "tested" for food by the more efficient^a organs there; if satisfactory it is swallowed, if not it is rejected. The fish will often take into the mouth in the same way particles floating in the water, some of which will be swallowed and others rejected in a manner similar to that described by Herrick (1903, p. 265) in the sea robin (*Prionotus carolinus*). In respect to the distribution of the organs of taste and the manner of feeding, carp would thus appear to be midway between such forms as the cat-fishes on the one hand, which have a well developed sense of taste over the entire body, and the sea robin on the other, in which taste is confined to the mouth.

Carp do not, however, do all their feeding at the bottom by any means. Where the water is shallow and clear they may often be seen swimming slowly about, skimming floating particles of food from the surface or working industriously along the stems of the water plants. At the surface they probably get small floating plants, insects or their larvæ, such as mosquitoes, May flies (or "June bugs," as they are popularly called along the lakes), etc., as well as the seeds of plants, and other substances which are dropped or blown into the

^a Herrick (1903, p. 267) says that "the delicacy of the sense of taste in the skin is directly proportional to the number of terminal buds in the areas in question." In the carp these buds are especially well developed on the "palate."

water accidentally. In feeding at the surface the fish swim about with the anterior part of the head showing, the mouth partly above water, partly below. The mouth is continuously opening and closing, and a sharp sucking or smacking sound is often produced, much as is made by a pig with his head down in the trough.

Much of the carp's food is obtained by foraging along the stems of water plants, and it also often eats quantities of the plants themselves. Many of these stems are covered with a considerable growth of algæ, bryozoa, etc., among which live a variety of minute, and even microscopic, plant and animal forms. Such stems as float on the surface or lie in a horizontal position in the water can be gone over very easily, and sometimes this appears to be done in a more or less systematic manner, the fish beginning at one end and working gradually along to the other. In order to get at the vertical stems the fish often turn on their sides, when the mouth can be closely applied to the rounded surface. They were also often seen to take the end of a floating stem or leaf, such as a cat-tail leaf, into the mouth and then pull and tug at it vigorously. Even if they did not get off pieces of the stem in this way, they undoubtedly pulled off the algæ and other substances growing on its surface. In one case I noticed a fish swimming about with a piece of partially decayed stem sticking from its mouth, but whether it was finally swallowed I can not say, as the fish swam away out of sight with the stem still protruding.

Few records of the food of the carp in this country made from examination of the contents of the stomach and intestine seem to have been previously reported. H. Garman (1888) reported on one specimen from Broad Lake, Ill., soon after the species began to be found in the waters of that state. According to him the food "consisted of vegetation and mollusks, the former constituting two-thirds of the material in the alimentary canal, and consisting of dead leaves and seeds. The seeds were, as far as could be determined in a hasty examination, chiefly those of trees and weeds. Elm seeds, ragweed seeds, and the seeds of *Polygonum* were noted. The mollusca were partially thin-shelled clams with an occasional *Sphærium*, and partly snails, such as *Physa* and *Lioplax*. All the matter was apparently gathered from the bottom. No trace of crustacean or insect food could be detected."

In August, 1900, Mr. M. C. Marsh collected carp stomachs near Bellevue, on the Mississippi River, near Omaha, and from Maumee Bay and River near Toledo, Ohio. Apparently no detailed study of these collections has been made, but Smith (1902), in his report on food fishes, gives a few general data. He states (p. 120) that the food was found to be largely microscopic, and contained in what was apparently a mass of mud passed on into the intestine, where he thinks the digestion probably takes place. Portions that were recognizable

macroscopically were rarely seen. In a few cases fragments of the higher water plants (e. g., *Ranunculus*) were found in the esophagus, while from the color of the small amount of fluid contents it was believed that green algæ might have been eaten. In the Maumee River the carp fed constantly and largely upon whole wheat that had been lost in the river a season or two previous in a grain elevator fire.

From the foregoing it appears that a large proportion of the material found by dissection in the alimentary tracts of carp was of vegetable origin. Since this material is eaten in such quantities and is digested in its course through the fish, as is shown by observation, the natural supposition is that it serves as food. And such is the opinion of most writers on the subject. Nicklas (1884), however, who discusses at much length the question of the proper food for the "artificial feeding" of carp, arrives at a different conclusion. It is his theory that these fish should be fed on materials especially rich in nitrogenous compounds, and in this connection he says (pp. 1011, 1012):

I have started my theory from the fact, which I know from actual experience, that the food of the carp is principally animal and not vegetable matter, and I find that in this I agree with most of the practical pisciculturists; but I differ from the views of Professor Nawratil (*Oesterreichisch-Ungarische Fischerei-Zeitung*, 1880, No. 35) when he asserts that carp, from their third year, live principally on fresh and decaying vegetable matter. This is contradicted by the experience that they are easily raised in ponds which contain but few plants, and by the circumstance that, if aquatic plants formed the exclusive, or even principal food of carp, vegetation would, in some ponds, be utterly destroyed in a few days after they had been stocked with carp, or at any rate in a couple of years, as carp are particularly fond of young shoots, which, by the way, show a pretty close proportion of nutritive matter [to animal food?]. Such an occurrence, however, I have never yet been able to observe, nor has it been observed by any other pond-culturist; whilst, on the other hand, it has frequently been observed that in carp-ponds vegetation becomes so rank and luxuriant that it has to be checked. As long as decaying vegetable matter has not been examined as to the quantity of nutritive substances contained in it, no opinion can be formed as to its suitableness for carp food.

My own observations have taught that the carp only takes to vegetable food when absolutely no animal food can be procured. I have not yet been able to ascertain whether the carp actually eats and digests decaying vegetable matter, because all I have so far been able to observe has been that the carp often swallows such matter, but almost immediately ejects it again, perhaps after having devoured worms and insects clinging to such matter.

I can not help feeling that Nicklas's judgment is influenced by his theory. Although he may possibly be right as to the kind of food that will be most economical in putting a given amount of flesh on a carp in a given time, it nevertheless seems evident, as a matter of fact, that carp do under natural conditions eat a large quantity of vegetable food. If Nicklas had examined the contents of the stomachs and intestines of the fish he observed, he might not have concluded that they ejected even all of the decaying vegetable matter that they ate. While it is not probable that the actually decaying vegetable matter

contains a great deal of nutritive material for the fish, this does not dismiss the whole question of vegetable food, as Nicklas implies; and while he says that carp can be raised in ponds which contain but few plants, being fed, I suppose, on animal food, on the other hand I have seen ponds in northern Ohio, where carp were retained from spring to fall, which contained practically no natural food at all, the water being supplied from artesian wells, and where the fish were fed exclusively on corn, barley, etc., and young "sowed corn," the plants being cut when 1 to 2 feet high and thrown into the pond. I am not prepared to say that these fish grew as rapidly as they would have if fed according to Nicklas's formulæ. But this does not concern us here. The important point is that carp can live very largely, if not entirely, on vegetable materials, and that under natural conditions in our open waters plants and plant products form a very large share of their food. The bearings of this, from an economic standpoint, will be discussed later on, where will also be considered the question of the extent to which carp may be injurious to the spawn and young of other fish.

Susta maintained that of its own choice carp would first select animal food, a contention in which he was supported by the observations of A. Fritsch in Prag and Emil Walter in Trachenberg. Karl Knauthe pointed out that these investigators had used exclusively the highly cultivated races, to which belong the so called Galician and Bohemian carp. He himself extended the investigation by comparing as to intestinal contents examples of the old Silesian carp and a new race of it bred by Gröger in Lauterbach with examples of the two quick-growing races mentioned above, using for the purpose fish of the same age. These fish, after each individual had been marked so that the four races could not be confused, were placed all in the same pool, which was rich in animal and vegetable food. In this way it was shown that the stomachs of the Galician and Bohemian carp were generally filled with small crustacea—chiefly *Daphnia* and *Cyclops*—as long as these were abundant, while insects and their larvæ were second only, in about the proportion of 3 to 1. Plant food was present only as it was taken incidentally with the other. In the cultivated Silesian carp the proportion of animal to plant food was about the same. The old Silesian "Bauernkarpfen," however, contained a great preponderance of vegetable materials, such as algæ, diatoms, plant débris, and the seeds of higher plants, and only a few animals, mostly small crustacea. As soon as the supply of lower animals in the pool was exhausted it became necessary for the Galician and Bohemian carp to adopt a vegetable diet as well. Moreover, Knauthe found the stomachs of these carp filled with a small species of pond snail which was abundant in the pool, and which both of the Silesian races spurned. From such and similar researches of Knauthe's it was shown that in

the spring the Silesian carp, though apparently well nourished, had reached a length of only 5 to 6 cm., while the Galician carp had grown to a length of 18 cm. The author answers the question, Wherein, under natural conditions, rests the ability for quick growth in fresh water fishes? by saying: "Partly, perhaps, in a better assimilation of the food, but mostly upon a better selection of the same. The richer this is in nitrogen, the greater, within certain limits, is its nutritive effect." (Zoologische Garten, Jahrgang 37, 1896, p. 345, 346.)^a

In order to determine the nature of the principal food of the carp in this country I have examined the alimentary tracts of a great many individuals. Many of these examinations were not made in detail, but only to determine the presence or absence of certain things, such as the eggs of other fishes. A list of the contents of stomachs and intestines of 33 carp, however, is given below. These examinations were made with more care than the rest, but are for the most part only qualitative, the relative quantities of the various materials being given only in rough approximates. The carp were from several different localities and a variety of conditions. The list is given in full because it is believed to be important to convey a very thorough knowledge of the nature of the food of the carp in our waters. I have never found large particles of food of any kind in the alimentary tract, the largest being strips of vegetable epidermis perhaps an inch long, wings and other portions of insects, small snail shells, and the like. It is stated that carp can grind or "masticate" thin food to a certain extent with the flat, knob-like pharyngeal teeth, and probably this in part explains the fact that what is found in the stomach is usually so much broken up. Houghton (1879, p. 17) even maintains that "portions of vegetable food are returned to the throat and remasticated by these pharyngeal grinders," though I know of no evidence in support of this hypothesis. The finely ground condition of the stomach contents leads to some wonderment among the fishermen, who are accustomed in other fish to find the food, such as smaller fish, swallowed whole, and one man always insisted to me that carp "digest their food in their heads."

1. Specimen from St. Clair Flats, June 30, 1901. *Chara*, small amount; May fly (ephemerid) wings and broken fragments, considerable numbers; insect larvæ, small; roots, decaying leaves, and epidermis ("bark") of aquatic plants, large amount; small shells and fragments; sand. All the *Chara* seemed to be packed in the small intestine. This was noticed in other cases, and seems to indicate that when the fish get among the *Chara* they eat a large amount of it.

2. Specimen from St. Clair Flats, July 3, 1901. Rootlets and other vegetable matter, such as would be found in bottom mud; coleopter-

^aFor a more detailed discussion of the processes of digestion and assimilation in the carp, the reader is referred to a later paper by Knauthe (1898).

ous larva, small; algæ; fine shell fragments with fine sand or mud, forming a "grit."

3. Specimen from St. Clair Flats, July 13, 1901. Large mass of remains of Ephemera, consisting for the most part of wings and of more or less broken up cercopods. (Fore wings 18 mm. long; one of the larger of the cercopods had 25 or 26 joints.) Very few other parts of the insects in evidence, except small opaque bodies with elliptical outlines, which were probably the eyes. The fact that the insects were adults would indicate that they were taken from the surface of the water either at the time of metamorphosing or when blown into the water later.^a This one carp must have contained hundreds of these insects. Prof. R. H. Pettit, entomologist at the Michigan Agricultural College, kindly examined the remains of these May flies (or "June bugs") for me, but was unable to determine the species from the material in hand.

4. Specimen 45 cm.^b long from North Bass Island, Lake Erie, July 19, 1901. *Chara*, considerable; copepods and ostracods, numerous; *Chironomus* larvæ or related forms; fragments of shells (mostly quite small), considerable; plant fibers.

5. Specimen 27 cm. long from North Bass Island, Lake Erie, July 19, 1901. Mass of food quite well digested. Much filamentous algæ (*Spirogyra* recognized) and diatoms.

6. Specimen 55.5 cm. long from Put-in Bay, July 27, 1901. *Chara*, bulk of material. packing intestine full in places, mostly in small pieces less than 1 cm. long; May-fly larvæ, 1 to 1½ cm. long, large numbers; shells, broken pieces, and small bivalves 2 to 4 mm. long, entire; *Chara* and considerable other vegetable matter, some of it probably *Philotria*; mud, fine débris, evidently bottom sediment.

7. Specimen 33 cm. long from Put-in Bay, July 27, 1901. *Chara*, mass of the material as in No. 6; amphipods, a number of small *Hyallala*-like individuals; broken shells, a very little; vegetable matter, a little besides *Chara*.

8. Specimen 38.5 cm. long from Portage River, about 3 miles above Port Clinton, August 6, 1901. About 90 to 100 c.c. of rather fine, dark material, composed almost entirely of finely divided vegetable matter. A few filamentous algæ.

9. Specimen 50.5 cm. long from Portage River, as above, August 6, 1901. A considerable quantity of blackish "mud", vegetable fragments, pieces of stem, etc., the principal constituent; one pulpy mass, apparently an unopened bud of some kind, possibly "lotus" (*Nelumbo*) or water-lily; insect larvæ, occasional, head only recognizable.

^a On Lake Erie I have seen windrows of the cast pupa cases of ephemerids being drifted about by the wind, and extending as far as the eye could follow them. If carp could have got among these at the time the insects were leaving they would have had abundance of food for a time.

^b Length of fish if in italics means total length—i. e., tip of snout to end of caudal fin; if in Roman type it is the length from tip of snout to base of caudal fin at middle.

10. Specimen 33 cm. long from Portage River, as above, August 6, 1901. Some 20 to 30 c.c. dark mud-like material, consisting mostly of plant fibers, fragments of stems, etc.; one young shoot (apparently of grass) about 18 mm. long.

11. Specimen 36 cm. long from Portage River, as above, August 6, 1901. Small amount of material of the appearance of fine mud; under the microscope seen to consist for the most part of finely divided vegetable matter and some filamentous algæ.

12. Specimen 47 cm. long from Portage River, as above, August 6, 1901. About 150 c.c. of material composed for the most part of vegetable matter—short pieces of stem, etc.; some pulpy vegetable matter, probably roots or bulbs of some aquatic plant; insect larvæ, occasional fragments.

13. Specimen 36 cm. long from Portage River, as above, August 6, 1901. Six to 8 c.c. of very fine material resembling mud in appearance, almost entirely composed of vegetable matter; vegetable fibers and some filamentous algæ recognized.

14. Specimen 44 cm. long from Portage River, as above, August 6, 1901. Only 2 to 3 c.c. of fine "mud", consisting of plant fibers, fragments of stems, etc.

15. Specimen 36 cm. long from Portage River, as above, August 6, 1901. Ninety to 100 c.c. of rather coarse dark material, mostly plant fibers and fragments; some pieces of leaves or stems 1 inch long, but most are smaller.

16. Specimen 32 cm. long from Portage River, as above, August 6, 1901. Small amount of very fine material. Most that is recognizable is portions of plant tissues—largely fibrous parts, and what appear to be the glumes of grasses.

17. Specimens 39 cm. long from Portage River, as above, August 6, 1901. Fifteen to 20 c.c. of dark grayish, almost black material, almost entirely composed of vegetable fragments.

18. Specimen 38 cm. long from Portage River, as above, August 6, 1901. Small amount of dark muddy material, mostly plant fibers and small pieces of other plant tissues; considerable filamentous algæ; insect larvæ (dipterous?), occasional.

19. Specimen 37 cm. long from Portage River, as above, August 6, 1901. Some 20 to 40 c.c. of fine, dark mud-like material consisting of vegetable fibers, fragments of stems, leaves, etc. Very little material in which vegetable cells could not be made out.

20. Specimen 34.5 cm. long from Portage River, as above, August 6, 1901. Fine material consisting mostly of filamentous algæ and partly digested tissues of other plants.

21. Specimen from "The Straits." 1 mile east of Cedar Point near Maumee Bay, August 12, 1901. Plants, pieces of stems, etc., considerable; algæ (filamentous), considerable; maxillæ of insects (?),

comparatively few; insect larvæ, few; diatoms; Vorticellæ; gastropods (?), few small fragments; much flocculent débris with small fragments of many kinds in it.

22. Specimen from Port Clinton, Ohio (from gill-nets in Lake Erie), November 16, 1901. Shell fragments, many, some of them 3 to 4 mm. in diameter; insect larvæ, fragments, caddis-fly (?) and some chironomid (?).

23. Specimen from Port Clinton (from Lake Erie), November 18, 1901. Shells, few small fragments; larvæ of caddis-fly (?), heads and other fragments; most of the mass of material appears to be made up of the nearly digested bodies of these larvæ. White-fish egg, one.

24. Specimen from Port Clinton (from Lake Erie), November 18, 1901. White-fish egg, one; larvæ of caddis-fly (?); entomostraca, mostly fragments; much of the material unrecognizable.

25. Specimen from Port Clinton (from Lake Erie), November 18, 1901. Shells, few fragments; algæ, few; apparently also other vegetable remains very finely divided; larvæ or worms of some kind, fragments; bulk of material unrecognizable.

26. Specimen from Port Clinton (from Lake Erie), November 19, 1901. Mostly fragments of *Chironomus* (?) larvæ.

27. Specimen from Port Clinton (from Lake Erie), November 19, 1901. Many remains of chironomid (?) larvæ (same as No. 26), much broken up; bulk of material unrecognizable.

28. Specimen from Port Clinton (from Lake Erie), November 19, 1901. Only small amount, about 2 c. c., in intestine; shell fragments; filamentous algæ; entomostraca, fragments, largely ostracods; caddis-fly (?) larvæ, much digested.

29. Specimen from North Bass Island (Lake Erie), November 27, 1901. Shells, 2 to 5 mm. in diameter, and shell fragments; ostracods, numerous, fragments of entomostraca in general.

30. Specimen from North Bass Island (Lake Erie), November 27, 1901. Shell fragments; entomostraca, fragments; insect larvæ, caddis-fly (?), fragments.

31. Specimen from North Bass Island (Lake Erie), November 27, 1901. Shell fragments, nearly one-half of material; ostracods, few; insect larvæ, caddis-fly (?), fragments; white-fish egg, one.

32. Specimen from North Bass Island (Lake Erie), November 27, 1901. Only a small amount of fine material, composed mostly of ostracods, Cladocera (?), and copepods, mostly fragments, some almost entire.

33. Specimen 46.4 cm. long from Port Clinton (seined in Lake Erie), August 31, 1902. Principal material appears to be seeds of some sedge; aside from these the mass is largely fragments of plants and unrecognizable débris.

As to whether the fish were wont to feed most at any particular

time of day, I obtained no very satisfactory data. Neither did I find any other conditions which seemed regularly to influence their feeding. It is stated by some authors—and I have some evidence to bear them out—that carp feed especially in the early morning and late in the afternoon. But I have frequently found them feeding at all other times of day, even in the hot midday sun of summer. This much seems to be true, however, that they are usually more quiet in the middle of the day; one does not hear them splashing about so often. In the late summer, the fishermen tell me, the carp in Lake Erie, at least, feed mostly at night. As to the time of year, Seeley (1886, p. 97) says, "Like many other fishes, it feeds most frequently before the spawning season." In Europe they are said not to eat at all during the winter months. In this country I have reason to know that they do, to some extent, at least.

BREEDING HABITS.

In Europe the carp is said to spawn principally in May and June, though in some cases the process extends several weeks longer. As well as I can ascertain, the same statement holds for the northern United States. In our Southern States and California spawning is apparently earlier, often beginning in April. In the waters contiguous to Lake Erie the height of the spawning season seems to be in the latter part of May and early June. On the St. Clair Flats I believe it is usually a little later on account of the lower temperature of the water, which comes directly down from Lake Huron. This temperature difference affects the time of spawning of the bass, dog-fish (*Amia*), and other shallow-water spawners as well, for I have found the eggs of these fish at the Flats when the season for them was entirely past in the interior lakes and rivers of the state.

The age at which carp spawn also depends largely upon the temperature. European authors state that they reach maturity in the waters of temperate Europe when they are 3 years of age, and the same probably holds true in general for the corresponding region in North America, though apparently they sometimes spawn, at least in the latitude of New Jersey, when they are only 2 years old (cf. statement of John H. Brakeley, Bordentown, N. J., Smiley, 1886, p. 757). Judging from other statements quoted in the same report, they commonly breed at the age of 2 years in the South (where they do not hibernate in the winter), and according to Mr. Poppe, of California (Poppe, 1880, p. 664), his fish spawned when they were only 9 months old. At the time of first spawning the fish will usually weigh 3 or 4 pounds and have a length of 15 to 18 inches.

At the spawning season, but before the fish have spawned, the females can usually be readily distinguished by their distended condition. Though the ova themselves are rather small, the number is

very large, and the reproductive capacity of a carp increases greatly for the next year or two after it begins to spawn. According to Hessel (1881, p. 871) a female weighing 4 to 5 pounds will contain on an average 400,000 to 500,000 ova. Day (1880-1884, p. 161) quotes other estimates, thus: A female of 9 pounds had 600,000 eggs (Bloch); one of $16\frac{3}{4}$ pounds had 101,200, one of $25\frac{1}{2}$ pounds 203,109 (Harmer); one of $21\frac{1}{2}$ pounds had 1,310,750, and one of $16\frac{1}{2}$ pounds had 2,059,750 (Buckland).

In the case of a female mirror carp from Sandusky Bay, which I weighed at Port Clinton June 22, 1903, I found that the ova comprised more than a fourth of the total weight of the fish. The fish before being opened weighed 17 pounds; after the removal of the ova with as little loss of blood as possible, the weight was 12 pounds 6 ounces, leaving 4 pounds 10 ounces as the weight of the ova. This is 27 per cent of the entire weight of the fish and 37 per cent (over a third) of the weight of the remainder of the fish after the ova had been removed.^a

This enormous fecundity is undoubtedly an adaptation to compensate for the dangers of the exposed condition in which the eggs are left after being laid, since they are merely scattered about on the vegetation in shallow water and are given no further care or attention by either of the parent fish. It may also help to explain the remarkable increase in numbers of the carp in our waters in a very short time, for if we suppose that the ordinary enemies of the eggs were not in the habit of searching for food in the kind of locality utilized by the carp for spawning, or at least were not present in large numbers, it is easy to see what an advantage this would give the carp, especially if the conditions were favorable to its growth in other respects. Furthermore, it would not be at all surprising if, as has been known to have happened in other cases, the increase in the quantity of food furnished by the abundant supply of carp eggs would favor the corresponding increase of some other fish or other animal which finds the eggs good eating. Or possibly, even, some form which has previously lived on other food may adjust its habits to the new conditions, and come to prey largely upon the spawn of the carp. It will rather be surprising if something of the kind does not happen, for in their struggle for sustenance nature's creatures are no respecters of person nor property, and it would be an unusual thing for a rich supply of food to be lying around long without some of them appropriating it. When this does occur, the phenomenal increase of the carp will undoubtedly be checked and the natural balance will again be approximated. One thing that militates against this in the case of the

^aDay (1880-1884, p. 161) says that continued cold weather may prevent carp from spawning, so that the process may last over several weeks or months, while some fish may retain the ova, thus occasioning disease. Bean (1903, p. 169) mentions that confinement of gravid females in a small tank may also cause them to retain the eggs, and he speaks of two fish that died from this cause.

carp and greatly reduces the danger is the short time required for the development of the eggs and the rapid growth of the young fish, which quickly takes them beyond the stage where they can be preyed upon by any but the larger of their enemies.

The general manner of the breeding of the carp is well known, but, so far as I am aware, the exact method has never been studied in all its details. This I found an exceedingly difficult thing to do in the open waters, where the opportunity to observe the proceeding is very largely a matter of chance. It is not so hard to find places where the fish are spawning, but the difficulty comes in getting close enough at the right time to see what takes place, and to have the water clear enough to see into when once close. These conditions I have never had the good fortune to have fulfilled, largely because the greater part of my work in the field has been after the spawning season of the carp was past. It is stated by many writers that at the time of spawning carp are so fearless, or at least so oblivious, that a person may approach very close to them and that they may then be easily captured (Hessel, 1881, p. 872). But I have always found even the breeding fish very shy. The place to make a careful study of the breeding habits would undoubtedly be in a moderately small pond, where the fish are confined to a limited area, and where they have become more or less accustomed to the presence of people in the vicinity. In the following description I shall rely for the most part upon my own observations, amplifying them where I can with the observations of others.

As is the case with the feeding, I could not ascertain that the spawning of the carp is confined to any particular time of day, though it apparently takes place more frequently in the morning hours. Hessel remarks that it is more frequent in warm than in windy and rainy weather, which agrees very well with my observations. At such times groups of fish may be seen swimming about at the surface, usually close together in a compact mass. In the marshes along the Sandusky River, where the best of my observations were made, the fish were in shallow water, one to two feet deep, and pretty well grown up with aquatic grasses, sedges, and flags, but with numerous open places from a few feet to a few rods in diameter, where the vegetation was not so abundant. The bottom was fairly solid, being composed of the roots of the plants and much dead grass. In these open places especially the carp could be seen, usually swimming slowly about with their dorsal fins and often a portion of the back projecting above the water. These also seemed to be the favorite places for depositing the spawn, though much is also deposited about among the thicker growth.

The spawning carp would usually be seen in groups consisting of one larger fish in the lead and a number of smaller ones following closely behind, making sometimes a string of six or seven fish in line, as is shown in the first figure on the next page. It is probable that

the larger fish ahead was a female and the others males, though I was unable to capture any of them at the time in order to confirm my opinion. This agrees, however, with the statement of Hessel (1881, p. 872), who says:

Two or three or more of the male fish keep near the female; the latter swims more swiftly on a warm, sunny morning, keeping mostly close to the surface, followed by the males.

The Germans call this "streichen," or running spawning. Other writers agree in this matter, so I shall speak of the larger fish as the

Carp spawning. A female followed by a number of males.

female and the smaller ones as males, for convenience in description. As they go along, the males each appear to be crowding and pushing in to get as near to the female as possible, those behind often seeming to nose under and displace the ones ahead of them. This often gives the appearance of more or less of a struggle, and is accompanied by considerable splashing. After a time they come to rest, and four or five line

Carp spawning. The fish at rest.

being each side of the female. They remain quietly in this way for a short time, perhaps one to two or three minutes, when one of them, presumably the female, starts forward and the others follow as before. While they are quiet, some of the fish of the group may not form in line with the others, but swim about in the vicinity, falling into line again as the procession moves forward.

I was unable to tell at what moment the actual spawning took place, though I observed that at times one of the males would work forward beside the female until they were swimming nearly side by side, when he would turn somewhat on his side and bring his ventral side close under the female. At such a time the body of the male usually shook with a sort of quick vibrating movement (though this was not always observed to be the case), and it was then, too, that the most violent splashing of the water occurred. It is probably at this time that the eggs are laid and fertilized. Here again my

observations seem to agree with those of Hessel (op. cit.), who describes the process as follows:

They lash the water in a lively way, twisting the posterior portion of the body energetically, and shooting through the water near its surface with short, tremulous movements of the fins. They do so in groups of two or three males to one female fish, and forming an almost compact mass. This is the moment when the female drops the eggs, which immediately are impregnated by the milt.

To this he adds:

As this process is repeated several times, the female drops probably only from 400 to 500 eggs at a time, in order to gain resting time, so that it will require days and weeks before it has given up the last egg.

Among the earliest observations on the spawning habits of the carp are undoubtedly those mentioned by Walton (1901 ed., p. 116), which are interesting on account of their curious mixture of more or less accurate observations and quaint ideas. Walton says:

I told you that Sir Francis Bacon thinks that the Carp lives but ten years: but Janus Dubravius has writ a book *Of fish and fish-ponds* in which he says, that Carps begin to spawn at the age of three years, and continue to do so till thirty: he says also, that in the time of their breeding, which is in summer, when the sun hath warmed both the earth and water, and so apted them also for generation, that then three or four male Carps will follow a female; and that then, she putting on a seeming coyness, they force her through weeds and flags, where she lets fall her eggs or spawn, which sticks fast to the weeds; and then they let fall their milt upon it, and so it becomes in a short time to be a living fish: and, as I told you, it is thought that the Carp does this several months in the year; and most believe, that most fish breed after this manner, except the Eel. And it has been observed, that when the spawner has weakened herself by doing that natural office, that two or three melters have helped her from off the weeds, by bearing her up on both sides, and guarding her into the deep. And you may note; that though this may seem a curiosity not worth observing, yet others have judged it worth their time and costs to make glass hives, and order them in such a manner as to see how bees have bred and made their honeycombs, and how they have obeyed their king, and governed their commonwealth. But it is thought that all Carps are not bred by generation; but that some breed other ways, as some Pikes do.

It may be of interest to give one other account of the spawning, though it adds nothing in the way of accurate details. Nicklas (1886, p. 548) quotes the following from Horak:

The female fish, or spawners, accompanied by the male fish, or milters, move rapidly along the edges of the pond, or near the calm surface of the water. The actual process of spawning generally takes place during the early part of the forenoon. I have taken careful observations of this process, and have invariably noticed that several milters always accompanied one female fish, and deposit their spawn, for not all females spawn, at the same time. Sometimes this accompanying degenerates into a regular chase which lasts until the act of propagation has been consummated. At the beginning of the spawning season the fish therefore gather in large shoals and move so close together as actually to touch each other. During warm, calm weather the spawning process is carried on at so lively a rate that the water is squirted 50 to 85 cm. [20 to 34 inches] above the surface.

In another place Nicklas (op. cit., p. 523) says that in the artificial propagation of carp the spawning ponds "must contain some stones,

and in some places aquatic plants, because the female fish like to rub against stones for the purpose of ridding themselves of the roe"—a statement that I know of no observations to support; it seems much more probable that the eggs are extruded entirely by muscular action while the fish are swimming about.

In pond culture the breeding ponds are usually stocked with male and female fish in a definite proportion; the unit is technically called a "spawning party." Usage differs as to the relative number of each sex that is best for stocking a breeding pond, but it is customary to put in a larger number of females than males. It is usually planned that each "spawning party" shall consist of one "milter" and two "spawners," or else two "milters" are provided for three "spawners," while for each three milters is added one 3-year-old male fish, known as a "driver" or "enticer," which is "not used for spawning, but simply to drive or entice the other fish to that process."

According to Hessel (1881, p. 872), the male carp at the breeding season assumes a secondary sexual character which is common to many members of the family at that time, namely, a various arrangement of "protuberances, like warts," which are generally known as "pearl organs." In the case of the carp these are said to occur on the skin of the head and back. I do not remember ever to have seen them on a carp myself, and have no mention of them in my notes. If they are regularly present in these positions they undoubtedly function as Professor Reighard has found they do in other Cyprinidæ and some of the Catostomidæ, in helping to hold the female at the time of spawning—observations which have not as yet been published in detail (abstract Reighard, 1904). The method of the carp would seem to be much like that of the sucker (*Catostomus commersoni*), where the two males lie one on each side of the female, holding her firmly between them with the help of the pearl organs along the sides and tail.

Hessel also states that sometime before the spawning season sets in the pharyngeal teeth fall out and are renewed each year. On this point I have no observations.

The eggs are not laid in bunches or masses, but are scattered about in the water, and, being adhesive, they become attached to the roots and stems of grass and other aquatic vegetation, or to whatever objects chance to cover the bottom where they are deposited. The fate of the egg probably depends to a large extent upon where it chances to become attached, for should it fall into the mud there would be little chance for its further development. The eggs develop rapidly, but the time required for hatching depends very directly upon the temperature of the water. In temperate regions, under favorable conditions, they are said to hatch in about twelve days, though if the weather be so cold as to lower the temperature of the water it may take them sixteen or twenty days to reach their full development. In the warmer waters of

our Southern States the development is more rapid; in a pond in Georgia, when the temperature of the water was 69°, the eggs are reported to have hatched in five to six days, while the following year, with the water still warmer, the whole time consumed for development was but forty-eight to seventy-two hours (statement of H. H. Carey, M. D., Smiley, 1886, p. 687). The young fish also grow very rapidly and in the latitude of Lake Erie reach a length of 4 to 6 inches the first fall.

DISEASES, PARASITES, AND ENEMIES OF THE CARP.

The most remarkable fact in this connection seems to be that, although deformed and misshapen individuals are by no means rare, carp in the Great Lakes region appear to be very strong and hardy and almost free from diseases, whether such as are due to parasites or to other causes. This fact impressed me especially while I was working with them in the fish houses on Lake Erie, where I had a good opportunity to compare them with large numbers of other lake fishes. One finds intestinal parasites in almost any of the other species in great abundance, but in large numbers of carp examined I have found parasites in the alimentary tract in only one case. This was a rather large fish, which had some 16 round worms, nearly chrome yellow in color and 2 to 2.5 cm. (four-fifths inch to 1 inch) long, hanging to the walls of the intestine. Their spiny probosces were buried in the intestinal wall in true acanthocephalous fashion, and it required a considerable pull to detach them. These specimens were referred to Mr. H. W. Graybill, who studied the parasites of many of the Lake Erie fishes in 1901. Mr. Graybill reports that these are a form closely related to *Echinorhynchus proteus*, though he thinks they are possibly specifically distinct from that type. He further states that in 1901 he found in a carp a single dwarf specimen of the same worm.

Excrescences of the integument, probably caused by sporozoa, are not infrequent on the wall-eyed pike (*Stizostedion*), and were occasionally found on other species, but I did not observe them at all on carp.

In one case I found a leech attached to the base of one of the pectoral fins of a carp, but unfortunately the specimen was lost before it could be preserved, so that I have been unable to have it identified. The only Lake Erie fishes on which I observed leeches at all commonly were the lake lawyer (*Lota maculosa*) and some of the cat-fishes (especially *Ictalurus*).

There can be no doubt that the lampreys must also be considered among the external parasites of the carp, though I have never myself seen one attached to a carp. The fishermen told me that "lamper eels" were "common" up the Portage River, and I often found them among the fish brought to the wholesale house from both the river and the

lake. This was the so-called silvery lamprey, *Ichthyomyzon concolor*.^a I inquired of the fishermen if they had ever seen the lamper eels attached to fish, and they said, "yes;" to the inquiry as to the kind of fish the reply was, "carp." On the 10th of August, 1902, I was assisting in making a seine haul of carp in the Sandusky River when one of the fishermen noticed a lamper "about 5 inches long" attached to one of the fish; it became detached, however, and escaped through the net before I could get to the place to see it for myself. Prof. S. H. Gage tells me that in his aquaria at Cornell University the young of the Cayuga Lake lamprey (*Petromyzon marinus unicolor*) have become attached to carp as soon as they were transformed from the larval stage and had left the sand. As carp are abundant in Cayuga Lake, as well as most of the other lakes in which this lamprey occurs, it seems very probable that during its free-swimming life the latter may be one of the important enemies of the carp, as it has been found to be of many other fish (Surface, 1898). In fact, Surface (p. 212) includes carp among those fish he has found dead with the marks of the lamprey on them.

Finally, under unfavorable conditions carp, like other fish, are susceptible to the attacks of fungus growths. So long as the water is pure there seems to be little danger of this, for I have seen carp that had been penned for long times whose heads were much bruised and abraded, but which were free from fungus. On the other hand, some young fish which I attempted to keep in an aquarium at Ann Arbor were soon attacked by a *Saprolegnia*, and I was unable to keep them alive for more than a few weeks on that account. The usual treatment with potassium permanganate and by immersing the fish for a short time in strong brine afforded only temporary relief. Smiley (1886, p. 754) gives the following with regard to carp attacked by fungus:

Statement of B. E. B. Kennedy, Omaha, Douglas County, Nebr., April 14, 1883.

FUNGUS.—On visiting our fisheries yesterday I find that many of the young carp are affected with a kind of parasite or fungus, which proves fatal. With some it appears on the back, some will have a strip nearly around the body, and some about the fins and tail. This fungus is easily removed, and the skin or flesh under it has the appearance as if the spot had been blistered. Several hundred have already died, and many more are similarly situated, and, unless there is some remedy administered, all will be likely to die. We have separated the affected ones from the others, hoping to stay the spread of the disease, if it is one. Those that show no fungus appear all right and take food readily.

NOTE BY PROFESSOR BAIRD ON FUNGUS.—When the carp are taken from their winter quarters for our spring shipments there seems to be a general tendency to the development of the fungus. It is probably due to the abrasions produced in handling,

^aIn color these specimens agreed more closely with the description of *Ichthyomyzon castaneus* Girard.

the development of fungus taking place in consequence of the emaciated condition of the fish after wintering. We do not find this diseased condition in the fish taken out of the ponds for the fall and winter shipments.

I am at a loss what remedy to suggest. It is possible that you may be able to destroy it by immersing the fish for a few seconds in a brine, of course allowing them to remain but a short time, and repeating the bath several times at intervals sufficient to allow the fish to recuperate from the shock of the operation.

According to European writers the carp in Europe apparently does not enjoy the wonderful immunity from parasites and from diseases that it does in our waters. A few quotations will suffice to make this clear. Seeley (1886, p. 98) says that in nature the carp lives 12 to 14 years, but survives much longer in confinement, though "subject to many sicknesses, deformities, and wonderful variations." Veckenstedt (1880, p. 673) remarks that diseases occur mostly to young carp; "polypes render the fish unfit for its full development; tape-worms constrict its intestines, make it lean, and finally kill it; lice torment it, and produce dropsy." And on this subject Day (1880-1884, p. 162) writes:

[It] is subject externally to fungoid growths, especially old carp; also the same mosslike appearance occasionally attack young fish which reside in foul or snow water, as well as blindness, epidemic fevers, visceral obstructions due to over-gorging on chickweed, ulcerations of the liver, malignant pustules under the scales termed small-pox by fishermen, carbuncles, and intestinal worms.

This difference on the two continents is probably in large part due to the fact that the carp described by the European writers were mostly fish whose ancestors for generations back were pond-raised fish, and which, owing to their long domestication, were more susceptible to the attacks of parasites and disease. These authors do not state what is the condition in the fish of the open waters of Europe in comparison with those reared in ponds, except Seeley's statement that carp kept in confinement are more subject to "sicknesses, deformities, and wonderful variations." Neither do we know the condition in this respect of those fish imported to the United States; hence it is difficult to say whether the apparently almost complete immunity of the Lake Erie carp is due to the fact that the fish originally brought to this country were practically free from parasites, so that few have been handed on to their descendants, whether it is due simply to the free, active life of the fish, or whether there is something peculiarly favorable to the fish in the conditions of our waters. The last seems to me likely to be the most important factor—that the conditions which have allowed such a phenomenal increase in the numbers of the fish have produced a hardy strain which is more than ordinarily resistant to the diseases that normally attack the species.

Professor Prince, commissioner of fisheries in Canada, makes special point against the carp on the ground of its susceptibility to diseases and parasites, and in a paper in which he strongly urges Canadians

not to undertake its culture he has the following to say on this subject (Prince, 1897, p. 35):

German carp are especially subject to parasites and contagious diseases. From their omnivorous and lethargic habits no fish are so readily attacked by diseases and parasites as carp. The "fish leprosy," described by Blake as a fungoid growth which spreads over the whole skin, turning the fish white and rendering it most unhealthy and a source of disease to all other fish, is essentially a disease of the German carp. Frank Buckland studied some of the diseases of these fish, and among others enumerated one malady which he called small-pox in the carp.^a

Tapeworms and other disgusting endo-parasites occur most plentifully in carp. One described by Harrington Keene taken from a carp of 16 pounds weight measured no less than 45 feet in length. Of all fresh water fishes the German carp are the most subject to external and internal diseases. This is, in fact, unavoidable in a family like the carps, with sluggish habits, a fondness for coarse and loathsome food, and a preference for muddy and almost tepid waters.

If any of the above is from Professor Prince's own observations I feel quite certain that he can not, at all events, have made them in this country. And if the German carp in Europe has been found to be subject to a number of diseases and parasites, it must be remembered that this is a subject upon which comparatively little is known in general, and that the carp, being a cultivated fish, has afforded opportunity for close study which most others have not. Certain it is that some of the fungus diseases to which he applies such awful names will attack almost any fish or other water animal under conditions unfavorable to the latter, and especially if there happen to be any abrasions of the integument. The carp's hardiness in this respect is one of its chief characters, allowing of its cultivation in ponds and small enclosures, conditions under which many of our native fish would succumb to fungus and other diseases in a short time. Then, too, contagious diseases, strictly speaking, are, according to present knowledge, extremely rare among fish, and I am not aware that any has yet been found which attacks the carp. The whole tone of Professor Prince's paper leads us to suspect that if he were studying a fish malady he would call it by some such name as smallpox in carp, whatever title he might use to designate it in other species.

It remains now to consider certain enemies which menace the fish, especially those which may attack them while they are in the ponds. These are in reality very few in such ponds as are in use in this country, since the impounded fish are all adults, and the adult carp has comparatively few serious natural enemies. With the young fish it is different, and the regular carp culturist has, of course, to deal with all these factors. The eggs are exposed to a great number of dangers, and especially are they open to the attacks of minnows and other small

^a The disease here referred to is apparently due to one of the Myxosporidia called by Hofer (1896, 1896a, 1896b) *Myxobolus cyprini*. This appears to be not uncommon in European carp ponds, but I am not aware of its ever having been reported on the carp in this country. I have not had opportunity to examine the recent handbook of fish diseases by Hofer (1904).

fish. It is a common statement, too, in books on the subject, that frogs are very destructive to the spawn and even to the young fish."

Walton (1901 ed., p. 115) even believes that frogs sometimes attack the adult carp, and after speaking of the mysterious disappearance of carp from ponds, relates the following curious story in defense of his belief:^b

And the like I have known of one that had almost watched the pond, and, at a like distance of time, at the fishing of a pond, found, of seventy or eighty large Carps, not above five or six; and that he had forborne longer to fish the said pond, but that he saw, in a hot day in summer, a large Carp swim near the top of the water with a frog upon his head; and that he, upon that occasion, caused his pond to be let dry: and I say, of seventy or eighty Carps, only found five or six in the said pond, and those very sick and lean, and with every one a frog sticking so fast on the head of the said Carps, that the frog would not be got off without extreme force or killing. And the gentleman that did affirm this to me, told me he saw it; and did declare his belief to be, and I also believe the same, that he thought the other Carps, that were so strangely lost, were also killed by the frogs, and then devoured.

And a person of honour, now living in Worcestershire, c assured me he had seen a neeklace, or collar of tadpoles, hang like a chain or necklace of beads about a Pike's neck, and to kill him: Whether it were for meat or malice, must be, to me, a question.^d

Among the other enemies to the young may be mentioned all the larger carnivorous fishes, turtles, water snakes, certain aquatic birds, especially the herons, and a few of the fish-eating mammals. Of the mammals, the only one that has to be especially guarded against in the ponds of this region is the muskrat, and that not because of any harm it does directly to the fish, but from the fact that it burrows through the embankments, causing leaks which may seriously lower the water level before discovered, and weaken the embankments themselves. Undoubtedly there must also be included among the enemies to the fish certain waterbugs, such as *Belostoma* (commonly known as the "electric-light bug") and *Ranatra*. An account of the ravages of these insects is given by Dimmock (1887), who quotes (page 69) the following letter, dated December 16, 1886, from Mr. E. A. Brackett, of Winchester, Mass. chairman of the Commission of Inland Fisheries of Massachusetts:

In October last, while drawing off the carp-pond, the water became very roily, and I noticed several young carp moving on the surface, sidewise, evidently pro-

^a Miss Mary C. Dickerson, of the Rhode Island Normal School, who has had much experience in keeping and observing our native frogs, has kindly sent me the following opinion as to the extent to which the North American species of frogs might prove injurious to fish ponds:

"Frogs would prove a menace to fish ponds, i. e., if in large numbers and if they were the aquatic frogs. We have only one in the East that would do any damage, that is *R. catesbeiana*, our common bullfrog, although there is one other, *R. clamata*, that will feed on fish to some extent if there is not a large supply of air and surface-water insects. In the West *R. pretiosa* is wholly aquatic, i. e., it takes its food from under water. All of our other frogs (some 9 kinds) would be quite harmless. They spend very little of their time in the water and do not take food from below the surface. My conclusions are from several years of laboratory feeding experiments."

^b In a paper which has appeared while the present report was in press Gill (1905, pp. 208, 209) quotes from other observations, which lend further credence to the belief that frogs, and toads as well, under the influence of sexual excitement, may attach themselves to fish in the manner described.

^c "Mr. Fr. Ru." [Walton's original footnote.]

^d Day (1880-1884, p. 162) quotes another and similar case from Pennant.

pelled by some external force. With a dip-net I took these young fish out, and found that in every case they were firmly held by a water-bug. The fish were dead, and the bugs apparently had been feeding on them. I had no means of determining how many of these bugs were in the pond.

Dimmock gives several references to literature on the same subject, and in the report of the United States Fish Commission for 1894 (1896, page 36) it is stated that carp in the ponds at Washington suffered from attacks of *Notonecta* and *Nepa*. As has been said, however, there is little to be feared from natural enemies in the temporary ponds and pens as they are conducted in this country, the greater dangers arising from impurity of water and other physical conditions.

ECONOMIC RELATIONS OF THE CARP.

Under this heading it is proposed to consider the relation of carp to aquatic vegetation, and to other fish and their spawn, as well as the secondary questions arising from these. The discussion is, for the most part, an examination of the numerous charges that have been made against the fish as to the damage it does, and in this respect is distinct from the succeeding chapter, which discusses the uses to which carp are and may be put. In Europe the mass of the literature on carp relates to its culture, but in this country it is safe to say that more has been written on the present subject than on all the others together. It has occupied our newspapers, our periodicals, and our scientific proceedings. Although so much has been written and said, however, this is nevertheless the subject on which perhaps the least is definitely known; the latter fact is probably an explanation of the former. Many extravagant statements have been made on the one hand as to the value of the carp, while on the other the English language has been searched to find words strong enough for its condemnation.

This state of affairs has, I believe, a very simple explanation. When the fish was introduced, the impression became prevalent that if one obtained a few carp, dumped them into any hole containing a little water which he chanced to have or could construct on his land, without further care he would always have a bountiful supply of excellent fresh fish. As recently expressed at a meeting of the American Fisheries Society, "almost every farmer had a carp pond in his front yard, back yard, or barnyard, or somewhere." These expectations were far in excess of what was ever claimed for the carp by its introducers, and it is little wonder that the people were disappointed. As it was seen that the ponds did not yield the phenomenal results expected, and as the novelty wore off, they were left neglected and uncared for, so that within a short time, through the agency of freshets and the undermining of embankments, the fish had gone to help stock the public waters in all parts of the country. For a time after this, comparatively little was heard of them, except that in local lists of fishes they grad-

ually began to be included as becoming common. But in many localities in recent years there has been an alarming decrease in the number of waterfowl, game fishes, and in many cases commercial fishes as well, and gradually the blame for much of this has been shifted upon the carp, which in the meantime has become the most abundant fish in some localities. Whether the blame was rightfully placed or not, remains to be seen. The game and food fishes seemed to be decreasing, the carp were undoubtedly increasing, and to many minds the inference was plain. It is a curious fact that those who are most concerned in the decrease of the fish and game are often the last to see that they themselves might in a measure be the cause. They are looking elsewhere for the explanation, and when a possible factor presents itself it is at once seized upon and made to bear the brunt of the whole charge. This is the point that I wish to emphasize here—that most of the statements that have been made as to the damage done by carp have been based upon very insufficient evidence; if founded upon direct observations at all, they were observations that, if not inaccurate, were at least inadequate. At best the evidence has been circumstantial, while on the other hand the defense has been either simply negative, or in places the attempt has been made to vindicate the carp on the grounds of its usefulness.

The denunciations of the carp have been so numerous, and in many respects so similar, that only a few quotations need be given to show their tenor. The specific charges based on direct evidence, so far as I have been able to find them, will be dealt with in more detail. What I shall attempt to do is to sift the evidence in as careful and impartial a manner as possible, adding to it what I have myself been able to learn in the prosecution of my studies on the subject. The best recommendation I can bring forward for myself as a juror in the case is that I approached the subject with little knowledge of the particular question, and, consequently, “unprejudiced and without previously formed opinions.”

It should be borne in mind that direct observations bearing on the various phases of the question as to the damage done by a fish like the carp are very difficult to make, and are in most cases largely matters of chance, while at the least they require a great amount of time. Take for example the relation of the carp to the black bass. The question is often asked, “Will a carp drive a black bass from its nest and devour the spawn?” If a person by chance happens to see the thing done, and is certain that he has interpreted his observations aright, there is the proof of the matter, and so it is settled. On the other hand, one might watch a bass nest for a long period—say, many hours each day—and never see a carp come near it, but one would still have no proof that it might not do so—his evidence would be only negative. To be sure, the longer the observation was continued the greater would

be the probabilities in favor of the harmlessness of the carp; but it seems to me that in most of these charges of destructiveness the burden of proof must rest with those that make the charges. If, however, in the case supposed above, the watcher should see a carp come near and be driven away by the bass, this would be good direct evidence in the carp's favor. All this serves to emphasize the importance of taking advantage of whatever opportunity chance may offer to throw light on these questions.

The principal charges that have been preferred against the carp have been enumerated in a preliminary statement of the present investigation (U. S. Fish Commission Report, 1903, p, 129) as follows:

(1) That the carp thrashes about and stirs up the mud, so that the breeding grounds of other fish are spoiled; (2) that the carp roots up the vegetation, destroying the wild rice, etc., and thus ruining good duck-shooting grounds; (3) that the carp eats the spawn of other fish; (4) that the carp eats the young of other fish; (5) that the carp is of no value as a food fish; (6) that the carp is of no value as a game fish.

To the first of the above might be added the charge that in stirring up the mud of supply reservoirs of water that is used for drinking purposes the water is made unfit for use. The first four of the charges will be considered here, the fifth and sixth will be discussed in connection with the food value and uses of the carp.

RELATION OF THE CARP TO VEGETATION.

The principal complaint against the carp on account of its destructiveness to aquatic vegetation comes from sportsmen, especially the duck hunters. They are almost unanimous in their condemnation of the carp on this account, but conversation with a number of them soon makes it apparent that while some are speaking from personal experience, and the opinions given are their own, many are merely repeating statements which they have heard, and which have become so stereotyped that they are easily recognizable to one who is investigating the subject. It so happens that the St. Clair Flats, and more especially the marshes bordering Lake Erie, are among the most famous duck-shooting localities in the Middle West, so that in this connection I shall confine myself for the most part to inquiries made there.

The most definite information I obtained as to the changes that have taken place in the aquatic vegetation in the last decade or so was near the mouth of the Sandusky River, where it opens into the bay of the same name. Mr. Fitzgerald, the keeper at the Winnows Point Club, who has lived in the region all his life, not only told me of the changes in the conditions as he could remember them, but allowed me to examine the records of the club in further substantiation of his observations.

It appears that the first carp were brought to that immediate vicinity in 1883 by D. W. Cross and Colonel Scovill, of Cleveland. A small pond was prepared near the clubhouse and, according to the records,

on May 20 was awaiting the arrival of the fish. These probably came soon after and were put into the pond on or before the morning of the 21st, for on that day there was a severe storm, the pond was flooded and finally broke out at 2 p. m., and all the fish escaped. The lot consisted of 20 leather and 20 scale carp. Later a large lot of young carp were sent to the club and were liberated in the marshes by Mr. Fitzgerald's father, and still more were planted by a tug which went up the river, putting in carp at various places along the route. To-day these fish are extremely abundant in this locality, and have been so for a number of years.

According to Mr. Fitzgerald's statement, coincident with the increase in the carp there has been a great decrease in the amount of wild celery (*Vallisneria spiralis*) growing in the shallower waters. He says that formerly, in late summer, the strip of comparatively shallow water extending some quarter to one-half mile from the clubhouse to the main channel of the river was thickly grown up with this plant. Its leaves were so abundant, floating on the surface of the water, that it looked almost like a solid bank, and it was only with great difficulty that a boat could be paddled through it. To-day this stretch is open water; only here and there do a few lily pads come to the surface. Much the same thing had been told me the previous summer by a carp fisherman, who for many years has acted as guide for hunters in the region. He affirms that the marsh has changed greatly in the last few years, and believes it is due to the carp. He says the carp root up principally the wild celery (*Vallisneria*), wild rice (*Zizania*) and deer-tongue (probably meaning both *Sagittaria* and *Pontederia*); and that the "canvasback celery" (*Vallisneria*) has been largely cleared out.

At the same time the duck shooting is said to have been rapidly on the decline. The canvasbacks (*Aythya callisneria*) and redheads (*Aythya americana*) especially have been growing scarcer and scarcer. The records of the Winnows Point Club, mentioned above, show a very marked falling off in the number of canvasbacks killed in about 1893, and conspicuously so in the numbers of both species in 1898-99. This is ascribed to the "absence of food." Since 1899-1900 not more than three or four canvasbacks have been killed by the members of the club each year. It is the custom now to sow wild-rice seed in the vicinity, but I do not know whether this has yet proved to be beneficial.

In order to learn something of the conditions and the sentiment of the sportsmen in the western part of Michigan, where there are many famous duck marshes, I sent a circular letter to the postmasters at Muskegon, Grand Haven, Holland, Saugatuck, and South Haven, and in each case received a reply either from the postmaster himself or from some one to whom the letter had been referred by him. The verdict from Saugatuck, on the Kalamazoo River, accorded very closely with that from Lake Erie. Mr. Charles E. Bird wrote that they have

no wild celery, but do have much wild rice. Since the carp have been planted, however, this has been largely rooted out; "they dig it up like a drove of hogs, and have about spoiled the marshes for ducks."

Mr. C. J. Dregman, of Holland, writes that carp are abundant in the lake (Black) and river there, and adds:

As to their destructiveness to wild celery or otherwise I have no reliable information to give you. There is comparatively little wild celery here, and that which does grow here seems not to be affected from year to year. Common report has it, however, that carp are destructive to fish eggs and nests.

Mr. George C. Monroe, of South Haven, does "not believe they cause any damage to plants along the river bank." At Muskegon, according to Mr. E. D. Magoon, "the marsh is full of channels and bayous, and these abound with carp." Wild celery, rice, and other duck food are found here, but he expresses no opinion as to the effect of the carp on these.

Considerable valuable testimony on the question under discussion is given by Doctor Smith in his report on the acclimatization of fish in the Pacific States (Smith, 1896, pp. 393-403). Several cases are mentioned where carp are reported as destroying the vegetation, most notable among which are observations made at what are known as the "Suisun Marshes." Doctor Smith (p. 397) quotes a letter from Mr. Ramon E. Wilson, secretary of the California Fish Commission, dated November 12, 1891, which states that certain portions of the marshes referred to above have been preserved by five shooting clubs for a period of ten years previously. The letter continues:

Each of these clubs has, from year to year, supplemented the natural and indigenous growth of vegetation by planting non-indigenous seeds and grasses, until about two years ago the ponds, ditches, and sloughs had so grown up with vegetable matter that upon the opening of the season it was almost impossible to push a boat through the dense growth. Last year, the season of 1890, it was discovered that a marked change had taken place. The cause was attributed to the winter, which was a rather severe one, in that there were many overflows and freshets occasioned by heavy storms. This year the change in the respect mentioned was much greater. It was early reported in the spring that there was very little sign of vegetable growth in any of the ponds. Investigation followed, and it was found that fish in large numbers, ranging from a few inches in length to 15 pounds in weight, had invaded the grounds and taken entire possession of all the waters. These fish came, say, in May and remained until about the latter part of July—that is, the bulk, but many remained later. We are convinced that these great numbers came to spawn. About August this great school, if you can so call it, suddenly disappeared—that is, the larger ones and the majority of the whole. Their going was not unlike the grasshopper in effect on vegetation—not a sign or remnant was left. The result is that to-day, where these same ponds have heretofore afforded unlimited food supply for surface-feeding ducks in the early part of the season and a like supply of celery bulbs for the canvasbacks and redheads for the balance of the season, there is absolutely not a single sign of vegetation. At the time mentioned I carefully examined the beds of the ponds and found them positively barren of vegetable matter. Notwithstanding the emigration, if it can be so called, of the larger fish, the waters are still alive with the same fish, ranging from 2 to 8 inches in length. These ponds, heretofore quite clear, are now nothing

more than mudholes. That this fish burrows in the mud there is no question. The beds of the waters are not unlike a sieve in appearance, with holes, round in form, ranging from one-half inch to 3 inches in diameter. The banks of the ponds and sloughs are quite like the bottoms. The fish have burrowed to the depth of a foot in many places, and it can be readily seen that it has been done for the purpose of getting at the roots of the vegetable growth.

That the fish which caused these disturbances were carp Mr. Wilson determined by sending specimens to Dr. David S. Jordan.

The testimony of Mr. John P. Babcock, at that time chief deputy of the California Fish Commission, is very similar. He is quoted as follows (Smith, 1896, p. 399):

The carp have destroyed almost all the wild celery of the lower Sacramento and Suisun Marshes. They reach all the ponds during high water, and, as soon as celery comes up, they eat the shoots, and, in many of the best ponds on the shooting preserves, have taken roots and all of the celery. They have not destroyed the tule grass to any noticeable extent, if at all. The damage has been to the better grasses. Many of the clubs planted wild celery in 1891, 1892, and 1893, but the carp destroyed it all, and it is claimed by observing men that the celery is entirely destroyed. The clubs resort every season to baiting their ponds with grain, and in these ponds the carp move in droves that W. P. Whittier tells me look like a tidal wave, as they move from one side to the other.

The most extravagant charge as to the damage done to vegetation by carp which I have seen is given by Prof. E. E. Prince, commissioner of fisheries for Canada, in a paper discussing "The Place of Carp in Fish-culture" (Prince, 1897). He says (p. 33):

In connection with this charge, a western United States paper tells of a rancher's visit to Portland, Oreg., to sue for damages he had sustained from the introduction of carp. He wished to find out whether he had recourse against the United States Fish Commission for the introduction of carp into the rivers of this section. He says these fish are destroying his meadows by eating his grass and grubbing up the roots. As the water overflows his meadow the carp follow it up in thousands, the small ones weighing about 3 pounds pushing their way up where the water is only 3 inches or so in depth and clearing off all vegetation, so that when the water recedes he will have mud flats in the place of meadows.

This statement appears the more credible, however, in view of some remarks made by Doctor Hutchinson, stationed at Portland, Oreg., in a letter discussing the value of the carp as an eradicator of the fluke disease of sheep. Doctor Hutchinson says (Stiles, 1902, p. 221):

All the bottom lands of this river [the Columbia] are subject to annual overflow, and at this time the carp clean the meadows as thoroughly as a fire. Every spear of grass, up to the very water's edge, will be eaten by them. They also have a habit of rooting all around the edge of this overflow as it gradually recedes.

Mr. Hessel, in reply to the letter from Mr. Wilson regarding the damage caused by carp in the Suisun Marshes (Smith, 1896, p. 400), states it as his opinion that the carp are in search of worms, crustacea, larvæ, etc., when they dig about the roots of the plants, and that the uprooting of the plants themselves is merely incidental. According

to him the aquatic vegetation in the Potomac River has not been damaged by carp, although these fish are abundant there. He says:

The carp is very numerous and prolific in the Potomac River. There are specimens from 20 to 30 pounds, but that they go for the water celery has not been noticed here as yet. Water celery grows in abundance in places where the river flows slowly, especially about the so-called flats, but any injury to its growth, or a reduction of its density, not to speak of its total destruction, has not been heard of, as far as I know, with two exceptions only, not attributable, however, to the carp, but to high water in the spring of 1882 and 1889, when every kind of vegetation was swept away by the floods, and consequently water celery disappeared from the river during the two years subsequent to those freshets.

I must not forget to call your attention to the fact that turtles, too, are not averse to a meal of water celery. Frequently I have seen "red-bellies" and "yellow bellies" feasting in the dense growth of Potomac celery upon that plant. Another point: For years I have kept quite a number of these species of turtles for ornamental purposes in a small pond about this station and fed them with water celery taken fresh from two ponds stocked with a great number of old and young carp, which never touched the celery, though it must be admitted they did loosen the roots in their hunt for animal food.

In conclusion, I reiterate that I am not familiar with the fauna of the Suisun Marches, but my impression is that, upon closer investigation, there may perhaps be found additional causes for the disappearance of the water celery and other vegetation therein, besides the undeservedly much-abused carp.

Even if Mr. Hessel's contention that the uprooting of the plants is a secondary result as the carp is searching about in the mud for animal food should be found to be true, the nature of the damage done would be the same. It seems, however, from the facts brought forward in the discussion of the food of the carp, that we should not be too hasty in concluding that it is altogether for animal matter that they dig up these plants; knowing as we do that they eat a large quantity of vegetable matter, it seems likely that they would take it whenever there is opportunity, so that in the case of the wild celery they probably eat the softer parts of the plant as well as the crustacea, insect larvæ, etc., dug up in the mud.

The fact that the wild celery in the Potomac was not being destroyed is a matter of more weight, but if the damage in other places is really perpetrated by the carp it merely goes to show that under certain conditions the fish does not harm the vegetation to a marked extent, while in other cases it does. This perhaps depends upon the relative abundance of other food. Furthermore, as Mr. Hessel suggests, there should be further investigation as to whether the carp is the sole factor in causing the rapid disappearance of these water plants. It must be remembered that we know very little of the obscure ecological forces at work which may cause great changes in the aquatic flora of a region. Since these reports come from such widely separated areas, however, the factor which is causing the destruction must be a very general one. If the damage were confined to the Great Lakes basin, for instance, it might be expected that some general phenomenon, such as a gradual

lowering of the water level in the basin, might be the cause, though it is difficult to see how that particular factor, even if it could be proved to exist, would effect the vegetation as has been observed. It would be expected as the result of such a lowering that the different floral zones would not in most cases be destroyed, but would merely reestablish themselves a little farther out from the original shores. Since a similar decrease is being complained of in many parts of the country, however, and within comparatively only very recent years, we would expect to find the same cause in all cases, and would look for some new factor coincident with the trouble. The planting and astounding acclimatization and propagation of carp seems to have introduced such a factor.

Then, too, there must be examined the more direct evidence against the carp. Vegetation has been rooted out of comparatively small ponds and reservoirs, where close observations could be made, and where apparently the only change in conditions that could account for it is the introduction of carp. And, finally, we know that these fish do root up many plants. In a pond where the carp were feeding in large numbers I have seen the surface of the water quite well covered in places with the uprooted vegetation, among which were to be seen whole plants of flags torn out bodily. In other places, when the *Vallisneria* was still young and did not reach nearly to the surface, I have observed the leaves floating about, recently torn from the bottom. Although it could not be determined with certainty in this case, it is very probable that carp were responsible. The roiliness of the water at the place served to strengthen the suspicion.

One can not be too careful, however, in drawing conclusions of this kind, since there are many opportunities to make mistakes. A concrete example may serve to illustrate the point. I was wading about in a little bay at the St. Clair Flats, where carp were abundant, and noticed many freshly torn up leaves of flags floating on the surface. It looked very much at first as if this were the work of the carp, but I later saw the agency at work—a muskrat, which dived to the bottom, cut off a leaf and brought it to the surface, floated there while he ate the succulent lower end, and then left it, to go down after another. These leaves were bitten off singly, however, while the flags mentioned above as uprooted by carp were torn up roots and all, probably not so much on account of direct pulling as by having the mud worked away from around the roots.^a The male dog-fish (*Amia calva*)

^aUnfortunately it was found inexpedient to make an experimental test of the effect of carp upon aquatic vegetation. This could be done by having two similar ponds or enclosures in which conditions are as nearly the same as possible. Into one of these should be introduced a certain number of carp, while the other should be left without them. If this were done in the spring, for example, an exact comparison could be made of the conditions in the two areas as the season advanced. The greatest caution should be taken in seeing that all conditions, except the presence of the carp, should be the same in the two enclosures.

also cuts off the young shoots when building its nest, and at such times these may be found floating on the surface of the water.

In conclusion, as to the relation of carp to aquatic vegetation, the evidence seems to be pretty strong that in general they are very destructive, and are probably, in large part at least, responsible for the great reduction of wild celery and wild rice that has been noted in many of our inland marshes in the last few years. This, in turn, has deprived certain ducks, especially the canvasback and redhead, of an important food supply, and has undoubtedly influenced their abundance to some extent in the localities in question. Whether the great reduction in their actual numbers can be laid to this cause is a very different question; and when we observe that the same complaint is being made of nearly all game birds and mammals not rigorously protected by law, it makes us look for an influence at work more general than the introduction of carp into our waters. Such an influence is to be found in the hunters themselves, and must be reckoned with in the case of the ducks as well as elsewhere. Whether it is more or less potent than the reduction of one of their sources of food is a question which remains to be settled. It is possible, too, that with the development of the country, and especially the opening up of extensive areas by irrigation, the ducks, instead of being actually so decreased in numbers as would at first seem to be the case, have scattered to new feeding grounds. A portion of the following quotation from the paper by Smith (1896, p. 399), mentioned above, refers to this possibility, while it also sums up in a concise manner the other aspects of the question:

In attributing to the carp the scarcity of canvasback and other ducks in a given region, there should be proof that the carp does and other fish do not eat and uproot large quantities of *Vallisneria*; and the influence of market hunters and indiscriminate killing by sportsmen must not be overlooked. The scarcity of canvasback ducks in most streams probably antedates the advent of the carp in noteworthy numbers, and, as in the Potomac, was coincident with spring shooting and with the activity of pot-hunters using swivel guns. Mr. John P. Babcock, chief deputy of the California fish commission, states that he thinks ducks in that State have changed their feeding grounds; miles of land in the San Joaquin Valley are now covered with ditches and miles of alfalfa now grow where a few years ago there was a desert; and the main market supply of ducks comes from that region instead of the Suisun Marshes. He thinks, however, that the carp have proved very objectionable in this region.

In consideration of all the evidence set forth above, although we are obviously unprepared to say to what extent, we seem forced to conclude that carp are, in some measure, detrimental to certain species of ducks.

ROILINESS OF WATER INHABITED BY CARP.

The extent to which carp stir up the bottom mud and make the water roily has been mentioned in speaking of its habits, and especially its manner of feeding. As a general thing this is one of the surest indications of the presence of these fish in waters that would otherwise be

clear; and it has several rather important economical bearings besides the mere fact that it usually accompanies or is accompanied by the uprooting of the aquatic vegetation. The constant roiliness of a body of water that has theretofore been clear must be an important ecological factor in determining the quantity and character of both the vegetable and, at least secondarily, the animal life inhabiting it. This will readily be appreciated when we consider that it decreases the amount of light that would reach to any given depth, thus depriving plants at that depth of at least a part of one of the most important conditions for their growth, while in the second place the settling of the sediment upon the stems and leaves of the plants acts as a mechanical hindrance to the ordinary processes of respiration. Where the balance is once upset in this way in a body of water where things have become adjusted to a certain set of conditions, it is difficult to predict just what results will follow in the readjustment to new conditions; but it is safe to assert that practically all the living organisms in the water will be influenced to some extent. Even if the vegetation were not uprooted by the stirring up of the mud of the bottom, it is probable that its abundance would be greatly reduced by the constant roiliness of the water. This would in all likelihood affect the plankton or free-swimming organisms as well, and thus greatly reduce the natural food supply of the fish. In the large bodies of water these conditions are ameliorated to a large extent, since by the movement of the fish from place to place they are often absent from a given locality for considerable periods, thus giving the sediment an opportunity to settle and allowing the water to become clear; and even in smaller areas the fish are not feeding all the time. But it must be admitted that where there are a comparatively large number of carp in a pond the water is kept in an almost constant state of roiliness. In the case of running waters there is a further tendency to impoverishment in the carrying away of the rich mud while it is held in suspension in the water. There has been no direct evidence collected, so far as I am aware, to show to what extent this may be effective. It has even been claimed by some that dikes and dams are weakened in this way, by the destroying of the vegetation that held the mud in place, and the loosening of the mud itself.

The roiliness of the water caused by carp in supply reservoirs has, in a number of instances, proved to be a serious problem, and is one which has to be met with promptness. The only practicable remedy is the removal of the fish. In some places this can be done with comparative ease by persistent seining; but more often, especially in large reservoirs which present a diversity of conditions, this method is not feasible. In some cases it may even be necessary, where the disturbance is very great, to withdraw the water and drain the reservoir for the purpose of getting rid of the carp. An interest-

ing case of the way this problem was met in Lake Merced, one of the reservoirs for the water supply of San Francisco, is reported by Smith (1896, p. 395) in the paper that has already been quoted. A number of sea lions put into the lake apparently did the work very efficiently: but unfortunately this is not a method that it is always possible, or at least, practicable, to apply. Doctor Smith quotes Mr. Babcock, of the California Fish Commission, as follows:

Carp have entered the Blue Lakes in Lake County. The Blue Lakes, three in number, were formerly very striking and beautiful bodies of water. A. V. La Mott now tells me that lower Blue Lake is so muddy that its beauty is gone, the carp keeping the water roiled all the time. Lake Merced, property of the Spring Valley Water Company, in the city and county of San Francisco, was so damaged by carp as to be almost useless to the company. The company employed four fishermen by the month to seine the lake, and during that time—some four months—bought 19 good-sized seals [i. e., sea lions] taken near Cliff House. These seals were placed in Lake Merced in 1891, and for a time the company employed men to go over the lake to pick up the pieces of dead carp that were so numerous as to be dangerous to the purity of the water. In the summer of 1895, at the request and expense of the water company, I engaged several Italian fishermen to go to the lake, and under our supervision they used all kinds of drag nets and seines in the lake and were unable to take any carp or any other fish than sticklebacks. The seals have grown very thin. Another effort was made in same manner with like results in the fall of 1895. I am of the opinion that there are no carp, big or little, in the lake at this time. The coming season the company will try again for carp, and if none is found the seals will be killed off and large-mouth black bass placed in the lake.

The planting and maintaining of large predaceous fish in waters where carp are objectionable will undoubtedly help to a large extent in keeping their numbers down, as they will prey upon the young carp. It is doubtful whether they will be of much effect in removing the larger fish, however.

Another point is mentioned in the above quotation which is often one of considerable importance, namely, the marring of the beauty of lakes and other bodies of clear water by carp, by keeping the water constantly muddy and roily. This is a problem which is apt to be encountered by park commissioners, and is to be met in the same way as in the case of the reservoirs. In parks, however, the usefulness of carp as a source of interest to visitors, who take pleasure in feeding them, may be considered as offsetting their undesirability in other respects, though gold-fish are usually preferred on account of their more showy appearance.

RELATION OF THE CARP TO OTHER FISH.

Perhaps more complaint has been made against the carp by anglers and commercial fishermen for its alleged destruction of other fish than by the sportsmen for its harmfulness to the feeding grounds of ducks. These complaints have come from nearly all quarters, and it will usually be found that they arise from a general sentiment rather

than from definite information. It is a noticeable fact that this sentiment is much less general, or may be largely replaced by one almost as unreasoning in favor of the carp's entire harmlessness, in regions where this fish is commercially valuable on a large scale. The charges may in a general way be divided into four headings: (1) That carp eat the spawn of other fish; (2) that carp eat the young of other fish; (3) that carp prevent the nesting of such fish as the basses; (4) that carp produce unfavorable conditions—chiefly roiliness of the water—that drive other fish away.

In the Great Lakes region the fishes that are generally conceded to be in most danger from the carp are the bass and other members of the same family (crappie, sun-fish, bluegill), and the white-fish. It is obvious that they can hardly affect directly such other commercial and game fishes as the wall-eyed pike and sauger (*Stizostedion*, commonly called "pickerel" on the Great Lakes), or perch^a (*Perca flavescens*), or trout; nor do I know of specific complaints of damage to the herring (*Argyrosomus*), sturgeon, or the true pikes (Esocidæ, "pickerel" of the inland waters). Most of these do not lay their eggs where they are likely to be troubled by carp, and some are probably considered able to take care of themselves. Still it seems that carp might easily affect wall-eyed pike, in cases where the eggs are attached to water plants; and if they affect white-fish they probably also affect herring, whose eggs are laid at the same time and presumably in the same places.

The first of the complaints enumerated above, viz, that carp eat the spawn of other fish, is perhaps the one that has been most persistently maintained. One can scarcely read a communication by one of the opponents of the carp without finding in it a statement to that effect. Nevertheless, few, if any, direct observations are recorded. The argument is something like this: Other fish, such as the bass, are decreasing, while the number of carp is, or at any rate has been, steadily on the increase; carp will eat practically anything; therefore, the decrease of certain other fish must be due in large part to the fact that the carp devour their spawn. What I wish to point out is that while the two premises may be true, the conclusion is by no means a necessary one. It can not be deduced from the above premises without other facts, and those facts have not been supplied. They might be of two kinds—first, direct observation of the eating of the spawn of other fish by carp; and, second, by the finding of the spawn of other fish in the

^a With regard to the perch, at the thirtieth annual meeting of the American Fisheries Society both Mr. Dickerson, of Detroit, and Doctor Parker, of Grand Rapids, Mich., expressed their opinion that the carp is indirectly harmful to the perch through the destruction of the vegetation. Doctor Parker remarks (Transactions of the Society, 1901, p. 124): "You must go back to the vegetable for the rehabilitation of waters. If you destroy vegetation and the larvæ, you destroy the minnows, and the perch have no minnows to feed on, unless they can eat the young of the carp, which they do not appear to do, but the black bass will eat the young of the carp and will thrive. Therefore you may look for an increase of the black bass, a decrease of the minnows, and also of those fish that feed upon the smaller minnows."

stomachs of carp. Although it is stated that carp do go about over the spawning grounds of other fish and that they devour the spawn, with the exception of the little given in this paper relative to the white-fish, I do not recall a single case that has been reported upon where sufficient evidence has been adduced to show that such is really the case. The absurdity, for example, of an assertion which has recently been made by a writer in *Forest and Stream* (Chambers, 1904) is obvious on the face of it. This partisan, after deprecating carp as a food fish and speaking of its habit of uprooting wild rice, adds:

When the stomach of one caught upon the St. Clair Flats was opened last autumn, it was found to contain at least a double handful of rice, while as an illustration of their destructiveness upon the spawn of other fish it may be mentioned that a *gallon of spawn* which had been devoured was taken from an 18-pounder—a weight which the carp frequently attains.

The italics are mine. The enthusiasm of partisanship has apparently led this observer into mistaking the spawn of the carp still in the ovary for that of some other fish which has been devoured, for it seems altogether out of the question that the stomach of one 18-pound carp should hold a gallon of spawn. A double handful of rice—wild, or Indian, rice (*Zizania*), I suppose is meant—might well be present. The greatest amount of material which I have ever taken from the alimentary tract of a single carp would surely amount to much less than a pint, though I can not say that by distention it might not hold more.

In my own researches at the St. Clair Flats, where the black bass were nesting in numbers, I spent much time in attempting to get direct evidence relating to the question at issue. Most of these observations were made in a small bay where the general water level in the deeper parts was about 3 to 5 feet. The bottom was composed of a fine clay, in most places rather light in color. Practically the only vegetation in this portion of the bay consisted of scattered groups of bullrushes, each clump usually radiating in long lines from a common center. The bass^a nests were in this open part of the bay, large circular excavations, a few inches deep, and usually appearing much darker than their surroundings on account of the removal of the top soil. As a rule they seemed to be placed near the lines of bullrushes, and were usually plainly distinguishable for a considerable distance on account of the clearness of the water.

Conditions about the margin of the bay were entirely different. Here the shallow water, 1 to 2 feet or so deep, was thickly grown up with vegetation—flags, sedges, lily-pads, etc.—and was succeeded by wet, marshy, grass-covered ground. The bottom here was largely

^a I believe these were the small-mouthed black bass (*Micropterus dolomieu*), though I find no record of the species made at the time.

soft, and black on account of the decayed vegetable matter. In this shallower area all about the bay carp were often very numerous.

In the first place much time was spent in trying to learn whether the carp ever intruded in the central portion of the bay where the bass were nesting. It seemed very probable that they would cross the bass nesting-grounds, at least in going in and out of the bay. But I was never able to observe a single carp actually on these grounds, though I at one time frightened a number of them in near shore which started out in that direction. A fyke-net was set with a view to intercepting any carp that might cross the tract covered by the bass nests, but with negative results. These fish are so wary, however, that it is very doubtful whether they would have entered the net had they gone that way. At another place I at one time had a large minnow seine drawn over a portion of bottom where a few bass were breeding and where I had reason to suspect there were carp present. Besides the small fish captured the seine brought in a bass, a pike, and two carp, which seems to show that they may at times go in close proximity to the area covered by the breeding bass, if not actually upon it.

In the bay mentioned above I built a scaffold at the border line between the bass grounds and the shore zone, with the idea of having a more commanding view of portions of both. On this I spent many hours of vigilant watch, and although a bass which had a nest near by soon became accustomed to the structure and resumed his care of the eggs in the nest, and although carp sometimes appeared within my range of vision in the water on the shoreward side, I never saw one of them on the outer side, where the bass nests were located. Since I have frequently seen schools of these fish lying quietly in water which seemed to present the same conditions, except that the bass were absent, I feel justified to some extent in concluding that as a general thing carp avoid the actual breeding areas of the bass.

The question has often been raised, and has been much discussed, as to whether a black bass would drive a carp away from its nest. A number of opinions were expressed on the subject at the thirtieth annual meeting of the American Fisheries Society, held at Milwaukee in 1901 (see the Transactions of that meeting, published in the same year, pp. 114-132). It appeared to be the consensus of opinion of the gentlemen assembled there that the bass is fully able to take care of itself, while it was further claimed by some that the bass were actually increasing owing to the extra supply of food furnished by the young carp. Below are given some extracts from the discussion referred to:

Mr. TITCOMB. Is it not a base slander upon the bass to intimate that it would allow a carp to touch its spawn?

Doctor BARTLETT. I should think so.

Mr. BOWER. I think that where bass and carp inhabit the same water it is natural that the bass should increase. We have been hatching black bass for a number of seasons in ponds where we have had an opportunity to observe their spawning

operations from the time the male fish begins to prepare the bed until a good many days after the hatching is completed, and we know that the male bass guards the bed against all intruders. He will put up the stiffest kind of a fight against any animal that approaches the bed with a view of preying upon the spawn. There is no danger of a carp ever looting the spawn from a black bass bed. On the other hand I do not think the carp can retaliate against the bass in any way, shape or form. While the bass is preying on the carp, the carp can not come back at them in any way. In other words, in the interchange of hostilities between the two species, the bass gets the better of it at every stage of the proceedings, and I think it is a perfectly natural result that the bass should increase in waters where there is an abundance of carp.

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Mr. LYDELL. I never have known but a single instance where the carp has destroyed the spawn of the black bass, and I never knew of their destroying any other spawn. I have handled and opened what few carp were caught at the Detroit river, Belle Isle, fisheries, during the last ten years, but never found any spawn in them.^a

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The PRESIDENT [Mr. DICKERSON]. I have made this assertion, that no carp ever got hold of an egg of a black bass unless Mr. Bass had first been taken off from that spawning bed. I do not believe there is such a thing as a carp ever having devoured a single egg from a black bass bed where the black bass was on the bed. Of course if the beds are deserted that is different, but as long as the bass is alive and guarding the bed, no carp ever got a single egg.

Other opinions were expressed, all with the same tenor; but it must be remembered that these are in most cases only opinions. They are expressed by practical fishermen, however, men who have had more experience with the black bass and with the carp than almost any one else in this country, and for this reason their opinions must be given weight.^b

In the Transactions of the Thirty-second Annual Meeting of the same society (1903, p. 54) a statement similar to the above is made by Mr. J. L. Leary. It is in part as follows:

As to his [the carp's] destroying the eggs or young fish, it is not a fact. My experience is that I could not raise the crappy in clear water, and I adopted the plan of putting so many carp in crappy ponds, and I raised some crappy and no carp, showing that the young carp are all destroyed by the crappy. The smallest sunfish can chase him away, for the carp is a big coward; the carp is a rapid grower and a good fish.

While we are discussing the case of the carp it may be well to give a little more fully the ideas of two members of the American Fisheries Society (Transactions of the Thirtieth Annual Meeting, 1901) as to the probable increase of these fish, as has been suggested above, on account of having young carp for food. Mr. Dickerson, of Detroit,

^a This fishery is not prosecuted during the spawning season of the bass; the statement is meant to refer to white-fish spawn.

^b This question should be tested by introducing a few carp into a bass breeding pond.

speaks of the complaints of the fishermen that carp are destroying the bass fishing on the St. Clair Flats, and then adds (p. 118):

But notwithstanding their claims the bass fishing on St. Clair Flats has been better during the last three years than at any time during fifteen years previous, and we have not planted any bass either. I can not account for it in any other way except that the environments of the carp and black bass are absolutely different. Black bass likes a clean, pure, sandy bottom, and the carp lives on a muddy, weedy bottom. I believe that the carp is a good thing in many waters where black bass thrive. I believe that the bass fishing at the flats has increased by reason of the food that young carp make for the bass, though he was not planted there.

Dr. S. P. Bartlett, of Illinois, who has always been a strong partisan for the carp, says (Transactions American Fisheries Society. 1901, p. 120):

When we take into consideration the fact that is so well known of the voracious habits of the black bass, it shows an all-wise provision of nature to supply a very large quantity of coarse fish to feed the other fishes, and I believe as firmly as I am standing here that if the carp had not been introduced in the state of Illinois, the buffalo having become almost extinct in our waters although it was once the great commercial fish that the bass would have been gradually taken out entirely from the list. As it is now, I want to repeat the statement that we have more black bass than ever, and our carp certainly have increased in a greater ratio than ever before.

This statement, so contrary to what is so often maintained of the bass at the Flats, seems the more plausible when we read in the Report of the Michigan Fish Commission for 1885 (p. 11) the statement that the decline of black bass in Lake St. Clair and the Detroit River was mentioned in the early eighties, and was said to be due partly to their being taken in nets, contrary to law, and partly because they were not protected. At this time they certainly could not have been influenced by carp.

Still more evidence along the same line is brought forward by Townsend (1901). After giving figures showing the increase in the catch of carp in the Great Lakes region and the Ohio and Illinois basin, he continues (p. 178):

These figures show an increase in the quantity of carp derived from the above-named waters amounting to nearly nine times the quantity yielded six years ago. During the same period the total fishery products of Lake Erie increased more than 15,000,000 pounds and those of the Illinois River more than 5,000,000 pounds. There are, therefore, no indications that the presence of the carp has produced any injurious effect on the native species associated with it, but, on the contrary, its presence may have a salutary effect, the young of the carp doubtless being food for black bass and other species. It is certain that the black bass has increased in the Illinois River along with the carp, the yield of black bass in 1899 being greater than ever before, amounting to over 70,000 pounds.

Regarding the relation of carp to some of the other fish I have only a few observations of interest. It seems a noteworthy fact, however, that I have found the dog-fish (*Amia calva*) on its nest, and apparently unmolested, right in the midst of a portion of the marsh which

was traversed daily by the carp in their search for food. Moreover, in the shore zone of the bay where the black bass were studied I found nests of an unidentified species of sun-fish or bluegill, and this was in the regular beat of the carp. The owners of these nests always left them upon my approach before I could get a good view of them, and immediately after their departure a number of small fish which had been swimming about in the neighborhood pounced in and began devouring the eggs. I succeeded in securing a few of these while they were committing their depredations. Those I captured were a small perch (*Perca flavescens*), a related form sometimes known as log-perch or hog-perch (*Percina caprodes*), and a small minnow (*Notropis whipplei*^a). All had their mouths and gullets crammed with eggs from the temporarily deserted nest. Here we have a suggestion as to one of the important factors that may tend to reduce the number of bass. At the St. Clair Flats, owing to the cold water brought down from Lake Huron, the bass usually spawn considerably later than they do in the interior waters of the state, which become warm more quickly. This is so late, in fact, that the close season prescribed by the law does not protect them at the time they are spawning, and as a consequence great numbers of them are taken by the bass fishermen directly off their nests. In addition, many are also speared, contrary to law, by certain lawless residents of the region. The poacher approaches as close as possible in a duck boat to the bass as it guards its nest, and when within long range throws his long-handled grain. Undoubtedly more bass are hit in this way than are actually secured, for I have seen numbers of them dead along the shore which showed the marks of the spear upon them. What the consequence is as soon as the parent fish is removed it is easy to see. Good food does not lie around unprotected long when there are hungry fish in the vicinity, and it is very probable that if a carp happened along at this time he would not hesitate to avail himself of the opportunity, for a familiar proverb might well be perverted to apply—all is food that comes to the carp's mouth.

In summing up with regard to the damage done by the carp to the spawn of other fish, especially the black bass, we find that there is little in the nature of direct observation, but what there is seems to point to the conclusion that there is little danger to the eggs of these other species so long as they are being guarded by the parent fish. That the carp does eat spawn when occasion presents is not denied even by Doctor Bartlett, the carp's greatest friend. He says, in the Transactions of the Thirtieth Annual Meeting of the American Fisheries Society, 1901 (p. 120):

In order that I might know positively what amount of injury had been done by the introduction of the carp into the waters of the Illinois, I took occasion when

^aThis minnow was kindly identified by Mr. T. L. Hankinson.

carp were first brought upon the market and the hue and cry raised as to their destructive qualities, to open and to be present while hundreds of carps were opened, to see if I could find in their stomachs anything that would indicate that they took the fry of other fish or spawn of other fish. I can not say that I have never found the spawn of other fish in their stomachs, but when I have found such spawn it has been of such a nature as led me to believe that it was such spawn as floated on the surface of the water, and that the carp took them in, in that sucking motion that he has, going around on the surface of the water.

From data given by Doctor Smith (1902) it appears that the blame for the destruction of shad eggs has been wrongfully placed upon the carp. He says that observations in the Potomac River show that the carp do not molest the shad eggs, as they do not go upon the spawning grounds. The greatest amount of shad spawn is consumed by cat-fish and eels. This was shown by having a large shad seine hauled over grounds where the shad apparently had just spawned. Many shad and alewives were caught, but mostly cat-fish (about 5,000 *Ameiurus albidus*) 6 to 18 inches long, and every one of these, so far as observed, was gorged with shad eggs.

With regard to the charge that carp devour the young of other fish, any damage that it may do in this way is certainly so slight that it need hardly be considered. It can not be said that carp never do capture smaller fish, for two or three cases have been reported—one where a carp ate some three minnows that were confined with it in a small aquarium (Gurney, 1860)^a, while in the other cases fish were said to have been found in the stomach. The carp is obviously unadapted by structure for capturing other fish for food. Its mouth is comparatively small and adapted to "sucking," while, furthermore, there are no teeth which could be used in holding living prey. Its only teeth are several rounded, knob-like structures situated well back in the "throat," and known as pharyngeal teeth, and are of service only for crushing and grinding.

As to the third and fourth points, that carp prevent other fish from nesting and that they produce unfavorable conditions which drive other fish away, I know of no proof on either side further than what has been brought out in the foregoing discussion.

I have chosen to consider separately the relation of carp to the white-fish, because the conditions in this instance are rather different and distinct from those in the case of any of the other fishes considered. Then, too, the white-fish fishery is one of the most important in the Great Lakes, and if it were found that the carp interfered seriously with the spawning of the white-fish it would be a very strong point indeed against him.

The white-fish of Lake Erie make an annual migration from the

^a "A specimen of the common carp, between 5 and 6 inches in length, was lately observed to devour three small minnows, each of about an inch and a half in length, which were confined in the same aquarium with him. One of these the carp seized immediately the minnow was placed in the aquarium and swallowed it whole, head foremost." (Gurney, loc. cit.)

deeper eastern portion of the lake to the shallow reefs at the western end, especially around the islands there, in order to deposit their spawn. The time of this migration varies somewhat with the temperature, but at an average the spawning usually begins in early November and is at its height during the middle or latter half of that month. The eggs are scattered loosely over the rocky bottom.

During my visit to North Bass Island in the summer of 1901, I heard much complaint by the local fishermen, who maintained that in the fall carp did great damage on the spawning grounds of the white-fish. Their statements may be summarized as follows: Carp are abundant about the Bass Islands when the white-fish are spawning; carp eat the spawn of other fish, especially white-fish; white-fish spawn has been taken from a carp's stomach; when carp are numerous on a reef, the white-fish are not there, being driven away by the carp. Carp are not caught here for commercial purposes to any great extent, and the prejudice against them was very strong. At such places as Port Clinton on the mainland, on the other hand, where carp are shipped in enormous quantities, and which is also one of the principal ports for the white-fish fishermen, I found the belief that carp were detrimental to the white-fish either entirely absent, or at any rate not nearly so strong.

In November, 1901, I proceeded to Lake Erie in order to make what investigations I could in the matter. At the time of my arrival, shortly before the middle of the month, white-fish were beginning to be caught in considerable numbers, though very few of the fish were ripe. A week or so later the numbers caught increased greatly, and the spawning seemed to be at its height. The season was an unusually stormy one, with strong northwest winds nearly every day, and one northeaster of several days' duration. The temperature was low during nearly the whole time and there were frequent snow flurries. The fishermen said that probably, owing to the rough weather, the fish did not go upon the reefs to spawn in such large numbers as was usually the case, so that the gill nets, set on the reefs, got comparatively few fish, while many more were caught in the pound nets in deeper water. I spent several days both at Port Clinton and at the islands; at the former place both pound-net and gill-net fish were brought in; the fish landed at the islands were all taken in gill nets.

Very few carp were brought in at either place, and none of them was large, averaging probably less than two pounds. On one day when I visited the pound nets with the fishermen, only two carp were taken. The stomachs of most of those examined at Port Clinton were empty, or nearly so, and in only two cases was any white-fish spawn found. At the time the preliminary statement of this work was published in 1903 (Report of the United States Commissioner of Fish and Fisheries, for 1902, p. 130) only a general and rather superficial exam-

ination of these stomachs had been made, and it was stated that no white-fish spawn had been found. When a more careful examination was made later, one white-fish egg was found among the contents of each of two stomachs. (See Nos. 23 and 24, p. 572.) The rest of the material was mostly remains of insect larvæ, entomostraca, shell fragments, and algæ.

November 27 was spent at North Bass Island and several dozen carp were examined. These fish, all small ones, 30 to 40 cm. (12 to 16 inches) long, were brought in directly from the gill nets, set in from 10 to 25 feet of water, and for the most part on the reefs. Most of the fish had some food in the alimentary canal, and in some cases the stomach was well filled, showing that they had been feeding very recently. Reference to stomachs No. 29 to No. 32 will show that the food was of the same general character as had been found at Port Clinton. Here, again, one stomach contained a single white-fish egg (No. 31).

The facts obtained lead me to quite a different conclusion from the assumptions made by the fishermen. That carp do occur on the spawning grounds of the white-fish is true, and, furthermore, they seem to be moving about and feeding in spite of the lateness of the season and the low temperature of the water. These are mostly small fish, however, and the number of them on the reefs appears to be comparatively small as well. The eggs of the white-fish, not being adhesive to any great degree, probably become widely scattered, and unless the carp were present in large numbers the relative number of eggs destroyed would be small; and that such is the case seems to be proved by the examinations of stomach contents made. That carp capture the young white-fish is even more to be doubted, and certainly no instance has been reported where such is known to have been the case. My conclusion is, then, that while the carp may eat some white-fish spawn, the amount so consumed is so small as to be practically insignificant, especially in comparison with the host of other forms which probably prey upon the eggs now as they have always done in the past. I suspect that by no means the least enemy to these eggs is the common mud puppy (*Necturus maculosus*—called "lizard" by the fishermen) which is often taken in numbers in the pound nets. And, furthermore, the danger to the white-fish spawn has been largely overcome in recent years by the operations of the Bureau of Fisheries, in hatching the eggs in jars and turning loose the young fish in the spring. It has generally been conceded to be due to this, and certainly in spite of the increase of carp, that the white-fish have been on the increase in Lake Erie in the last few years. The catch in 1901 was an especially good one, and was said by the fishermen to exceed any for many years previous.

FOOD VALUE AND USES OF THE CARP.

At the time of the introduction of the carp to this country a greatly exaggerated idea became prevalent as to its value as a food fish, or, at least, as to its qualities as a food fish. This will be noted by a glance at the statements which were sent to the Bureau of Fisheries by those who had received the fish, and which were compiled and published by Smiley (1884, 1886, 1886*a*, etc.) a few years after the fish first began to be distributed. Some of these enthusiasts even went so far as to say that the flesh of carp was of a better quality than that of the trout, white-fish, salmon, and many other of our finer fishes. How such a notion should have become so generally distributed it is difficult to see, for at no time were such claims made for the carp by those who were most interested in its introduction, although it is true that probably most Americans will hardly agree with Mr. Hessel (1881, p. 897) when he asserts that it "is one of the most excellent fresh-water fishes." Mr. Hessel, however, was a German, and in Germany the flesh of the carp is much esteemed. What early habitude may do in determining likes and dislikes as regards food is illustrated by the fact that Germans who live near the Great Lakes, where they could easily get what we should consider better fish, often eat carp from preference, while the American fishermen rarely, if ever, use the carp themselves. As will be mentioned later, the reason for this is perhaps a matter of cooking.

At the present time the popular prejudice is in most parts of the country generally against the carp as a food fish. It is even stated by many that it is utterly worthless. A common complaint made against it is its muddy flavor, and that this often exists is admitted even by those who like the fish best. This flavor has, in fact, always been recognized by carp culturists in Europe, and special precautions are taken to avoid it. It is said to be present in those fish which have lived in very muddy places, especially where the water is stagnant and the temperature rather high. If the carp are removed from such places and kept for a short time in fresh running water, the muddy flavor is claimed to be removed entirely.^a

In the chapter dealing with the carp in Europe, it has been shown how extensively this fish is used for food there, especially in Germany and France. It is the custom in many places there to keep the fish alive in tanks at the market, thus selling them to the customers not only in a fresh but actually in a living condition.

Many methods have been given for cooking carp—undoubtedly any

^a Day (1880-1884, p. 162) says: "To improve their flavour Mr. Tull (Phil. Trans. Roy. Soc., 1754, p. 870) castrated these fish and found that subsequently they grew more rapidly, fattened more readily, and were of a superior flavour." Similar experiments have frequently been mentioned, especially in the older works, but there seems to be no record of the attempt having been made recently. In this connection see Weddige (1882).

German knows what are best; but I do not feel competent to judge of them. In general, it would seem that the flesh is best boiled and baked and prepared with some sort of dressing. Dr. S. P. Bartlett (1903, p. 49) gives the following suggestions:^a

I feel sure that most of the prejudice to the carp as a table fish is from the fact that they are too often taken from the warm water, fried and broiled without preparation. Their rapid growth and the warm water they are taken from, has a tendency to make them soft. I have found the best mode of preparing them as follows: Kill as soon as caught, by bleeding, taking out all of the blood. Skin, soak in salt water for several hours, then parboil and bake, basting frequently. They are frequently served here as a boiled fish, covered with proper dressing. It takes but a slight stretch of the imagination to place [them] on bill of fare as anything from bluefish to buffalo. To-day I had bluefish served with my soup at one of the principal hotels and it would have passed as such with the average man, tell-tale bones, however, said carp.

Carp is probably more often served under the name of some other fish than is generally suspected. Mr. John W. Titcomb gives an instance where it was served at his instigation which shows that this fish when well prepared compares so favorably to many others that few suspect the difference. At the dinner in question there were 224 people present. Mr. Titcomb's account of it is here given (Titcomb, 1902, p. 36):

That the carp is unfit for food, as claimed by many sportsmen, may be contradicted by the statement that at the dinner of the Vermont Fish and Game League held at Burlington, Vt., in January, 1902, at which were entertained the members of the North American Fish and Game Protective Association and representatives of the fishery departments of three Provinces in Canada, the carp was served under the title of "baked red snapper," and was a very palatable dish. The deception was not planned by the hotel managers, but at the request of the president of the league in order that the carp might be fairly tested as to its edible qualities. While a great many of those who ate the fish knew that it was not the genuine red snapper, it is probable that not one of the guests had any idea that he was eating the despised carp.

It is probable that many hotels and restaurants would find it profitable to have carp regularly on their bills of fare, especially such as have considerable German patronage. The report of the Commissioners of Inland Fisheries and Game (of Massachusetts) for 1893 (published in 1894) quotes the statement that at that time at least one restaurant in Cleveland regularly had carp on its bill of fare; and a

^a Doctor Bartlett also gives a recipe for "carp omelet" or "carp jelly," said to be of Swedish origin. It was given to him by Doctor Weiss, of Ottawa, Ill., who declares that the perfected product is equal to the imported fish jelly that brings \$1 per pound. The recipe is as follows:

Take a 6 or 8 pound carp; scale and skin. Leave head and skin [fins?]. Cut into small pieces and place in boiling water just sufficient to cover, and add salt, coarsely ground pepper, allspice, and a bay leaf or two. Boil about twenty minutes or until perfectly soft. Remove from the fire, remove pieces of fish from the water, but preserve the water. Break the pieces so as to be able to remove all of the bones thoroughly. Skin fins and head pieces. Strain liquid through a colander and if necessary add a cupful of gelatin, previously dissolved, to this liquid. At the same time add such other pieces as may be desired. Add the original pieces of fish to the liquid or gelatinized liquid. Stir and place on ice until solidified.

recently published menu^a of the café luncheon of the Waldorf-Astoria, New York, for April 16, 1902, contains the item, "Carp, Rhine Wine sauce" at 65 and 40 cents.

It is not maintained, however, that the attempt should be made to put carp on an equal footing with our admittedly finer fishes. It is merely desired to show that if the prejudice at present prevailing against it as a food fish could be removed it would be much more extensively used than at present. Even now hundreds of tons of carp are being consumed yearly in the larger cities of this country, though the demand can still not be considered equal to the possible supply. The amount of these fish now used will be considered under the subject of the carp fisheries (p. 617). The sale is at present mostly limited to the poorer classes in the cities, and especially to the Jewish people. For this trade it is necessary that the fish be shipped "in the round," and those that have previously been cleaned will not be accepted.

Several methods of specially preparing carp have been tried to some extent in this country, but none of them has as yet been attempted on a large scale. I was told that canning carp had been tried in Cleveland, but was unable to get any definite information on the subject. If the dogfish of our coasts, a species of shark, can be put up successfully in this form, as is now maintained, it seems that as much might be expected of the carp. The greatest difficulty would be, in both cases, in overcoming popular prejudice and in establishing a market for the product.

A few firms along Lake Erie have been smoking a considerable quantity of carp, which has, however, never had a wide market, but has been disposed of locally. For this purpose the larger fish are used, weighing usually 12 to 15 pounds. With a sharp knife the skin and scales are cut off in broad strips (about three to a side), the cuts not going so deep, however, but that the imprints of the scales still show on the flesh. The head, viscera, and fins are all cut away, and the fish is then cut up into transverse sections or "steaks" some 2 or 3 inches in thickness. This last process is readily accomplished by means of a sharp knife fixed in a long-handled lever, as is shown in figure 4, plate II (the operator to the left). Two skilled operators can prepare a large number of fish in this manner in a comparatively short time. The steaks are strung on long iron rods and are smoked in the ordinary way. I was told that this product was sold as smoked carp and retailed at about 15 cents per pound. The claim was made that "except for the bones it could not be told from smoked sturgeon," and that I myself tried I found to be very palatable. At a retail market in Sandusky I actually found smoked carp on sale at 18 cents per pound under the name of smoked sturgeon. The larger fish are not readily

^aThis menu has been reproduced in Transactions American Fisheries Society, Thirty-second Annual Meeting, 1903, p. 123, and in the Report of the [Illinois] State Board of Fish Commissioners, 1900-1902.

sold in the round, those of 3 to 5 pounds' weight being considered best for cooking, and it seems that smoking should be an important way to utilize the less desirable size. I am unable to give even approximate figures of the amount or value of this particular product at this time, but it seems to be an industry which is capable of being developed upon a paying basis to a much greater extent than at present.

Wholesale dealers who have tried the experiment of salting carp down, as is done with the herring, and thus holding them over to a season when they would demand a higher price, inform me that the experiment was not a success. This is probably due largely to the fact that the Jewish people are by far the largest consumers of carp in this country, and they want the fish as fresh as possible. It was also the opinion that the salting had a deteriorating effect upon the quality of the flesh. It is a common practice in most of the large fish houses, however, to freeze large quantities of carp when the supply is greatly in excess of the demand at the time and to hold them over in this condition until there is a market for them.

The scarcity of sturgeon and the high price brought by caviar naturally suggested to many the possibility of using the roe of the carp for their purpose. While the eggs are small, a single large female often contains a large quantity of them (see p. 574), and during the breeding season carp roe could be obtained in abundance. But those on the Great Lakes who have attempted to manufacture caviar from the roe of the carp have all reported a failure, complaining that in the process the eggs turn pink or red. Inquiries have been made as to whether this could be avoided. This change of color is probably always characteristic of caviar made from carp eggs, as is evidenced by the following quotation from Walton (1901 ed., p. 116):

But it is not to be doubted but that in Italy they make great profit of the spawn of Carps, by selling it to the Jews, who make it into red caviare, the Jews not being by their law admitted to eat of caviare made of the Sturgeon, that being a fish that wants scales, and, as may appear in Leviticus xi, by them reputed to be unclean.

It is possible that similar caviar made in this country would find a ready sale in the large cities, such as New York and Boston, where there are large settlements of Jews.

It is said that in some parts of Europe "the palate, commonly termed the 'tongue,' is considered a great delicacy."

In common with numerous other fishes certain parts of the carp were formerly considered to be of great medicinal value. Thus Walton, on the page quoted above, says that "physicians make the galls and stones in the heads of Carps to be very medicinale."

Besides being of value as an article of food there are a number of other ways in which carp may prove to be most useful. Perhaps the most important of these is in helping to keep in check the increase of noxious insects which pass their larval stages in the water, and especially

that ever-present cosmopolitan pest, the mosquito. Howard (1901, p. 161) emphasizes the importance of fish in this respect and gives an instance where carp are said to have been very effective, though he himself doubts whether carp could have been the fish that destroyed the larvæ. He says:

It was stated a number of years ago in *Insect Life*, that mosquitoes were at one time very abundant on the Riviera in South Europe, and that one of the English residents found that they bred abundantly in the water tanks, and introduced carp into the tanks for the purpose of destroying the larvæ. It is said that this was done with success, but the well-known food-habits of the carp seem to indicate that there is something wrong with the story. If top-minnows or sticklebacks had been introduced, however, the story would have been perfectly credible, and it points to the practical use of fish under many conditions. Some years ago Mr. C. H. Russell of Bridgeport, Conn., described a case in which a very high tide broke away a dike and flooded the salt meadows of Stratford, a small town on the north side of Long Island Sound. The receding tide left two small lakes nearly side by side and of the same size. In one lake the tide left a dozen or so small fish, while the other was fishless. An examination by Mr. Russell in the summer of 1891, showed that while the fishless lake contained tens of thousands of mosquito larvæ, that containing the fish had no larvæ.^a

From the results of the stomach examinations recorded in the earlier pages of this report it does not seem that Howard's conclusion that carp did not destroy the larvæ in the tanks in question is warranted. While it is true that no mosquito larvæ were found among the intestine contents examined in connection with the present investigation, this may have been due to their small size; the fact that in some cases the food of the fish seems to have consisted almost entirely of insect larvæ makes it probable that those of the mosquito would be taken as well. Since it is reasonable to suppose that there was little or no other food in the tanks mentioned in the above quotation, it is all the more probable that the carp would there have eaten the mosquito larvæ, and I see no reason to doubt the original statement. It may well be that among our native fish there are some species, such as the stickleback and top minnow, which are better adapted to this purpose than the carp, but the latter is not for this reason a negligible factor. Undoubtedly many ponds that annually breed millions of mosquitoes need only to have plenty of fish introduced in order to abate the nuisance. If carp will do this as well as other fishes, it will serve a double purpose, as it can also be used for food.

Another, and perhaps even greater, benefit to be derived from the presence of carp has recently been suggested in a bulletin by Doctor

^a In February and March, 1904, I had similar opportunity to observe the efficacy of fish in keeping the waters where they are present free from mosquito larvæ. About the hacienda at Chichen-Itza, Yucatan, there are a number of large tanks which are kept constantly filled with water for the stock and for other purposes. In some of these tanks mosquito larvæ were very abundant; but in the others, into which a few small native fish, locally known as "mojarras" (*Heros urophthalmus*), had been introduced, none were to be found. The same was true of two natural pools in the vicinity where these fish lived, while, on the other hand, large numbers of larvæ could be found in small hollows in the rock and other places where the rain water had been standing for a few days.

Stiles (1902), of the United States Bureau of Animal Industry. It was learned by Doctor Hutchinson, an inspector of the Bureau in Oregon, that sheep from the lowlands along the Columbia and Willamette rivers, where carp are numerous, are much freer of the fluke disease than those from other sections of the country, and it is suggested that the parasites (*Fasciola hepatica*) which produce the disease may be destroyed by the carp while in a cystic state (cercariæ) and attached to the leaves of grass or while they are in their intermediate host, the common fresh-water snail *Limnæa*. In a letter to the Bureau, dated December 2, 1901, Doctor Hutchinson writes:

Prof. C. V. Piper, of the Washington Agricultural College, in conversation with me, mentioned the theory which I find is, as he said, extant in the minds of many farmers along this river, namely, that "leeches" [liver flukes], which were formerly numerous in the livers of cattle and sheep, have to a considerable extent disappeared since the introduction of carp into the waters of this river.

While, of course, the farmers' idea is that the carp now consume the leech which, according to their view, the cattle formerly swallowed with the water while drinking, it is possible that there may be a practical connection between certain peculiar habits of this fish and the noticeable freedom from fascioliasis among the cattle and sheep ranged on the bottoms adjoining streams in which these fish are found, compared with animals coming from other sections where carp are unknown. About 75 per cent of the cattle and sheep coming from the western slope of the Cascades, exclusive of this Columbia River bottom, are infested with *Fasciola hepatica*; but from this particular portion only about 5 per cent are so infested.

And in another letter of later date (January 4, 1902) he adds:

I am able to say that fascioliasis is much less common in animals from the lower Columbia and Willamette slough lands than from any other swampy districts of Oregon or Washington.

The carp have the more chance to destroy these parasites since the bottom lands are subject to annual overflow, and at such times the fish spread over the meadows and root out and eat much of the grass. Although I do not know that any species of *Limnæa* has been actually identified in the alimentary tracts of carp, there can be no doubt, as Doctor Evermann states in a letter quoted in the above bulletin, that carp do eat them when they are at hand. Doctor Stiles appears to have justification for his final statement that "the action of the carp in this case appears to be very strongly supported by the facts stated, and it seems that the introduction of carp into fluke districts generally would result in a great decrease of liver-fluke disease."

The Bureau of Fisheries, as well as some of the state hatcheries, have found that young carp make very good food for black bass, and according to the reports of the Bureau at least 1,000,000 of these small fish must have been used in this way in the years from 1894 to 1896. They have also been used to put into trout ponds to clean out the foreign matter, to destroy the algæ, etc. (Report United States Fish Commission for 1900 (1901), p. 57). It is possible that small carp would

make excellent bait for bass, and perhaps other fish, but I do not know that they have been tried.

On account of its hardiness and the readiness with which it will accommodate itself to small quarters the carp makes an excellent aquarium fish for exhibition purposes. At the large market in Boston there are several large carp in a glass tank so small that the fish now have barely room to turn around. It is said that these same fish have been there for a number of years.

When carp began to be common in Lake Erie it was suggested by many that perhaps the air bladders, or "sounds," as they are called, might be used for the manufacture of isinglass, which is extensively used in clarifying wines and in similar ways. At present about the only fresh-water fish whose sound is used for this purpose is the sturgeon, and the sturgeon fishery is comparatively so small that the sale of the sounds amounts to very little commercially. Those who had tried to use carp sounds for this purpose had not been successful. Nevertheless, at my suggestion, Mr. John Tufts, of the Cape Ann Isinglass Company, made further tests on some sounds which were procured for me by Mr. Cleaver, of the firm of R. Bell & Co., Port Clinton, Ohio. Mr. Tufts writes me as follows:

In regard to the carp sounds which you sent me, will say that I have tested them and find that [they] will not answer our purpose, inasmuch as they do not seem to contain any glue.

Finally, where carp are taken in greater numbers than can be used for food, or where the attempt is being made to rid waters of them, they can always be used for the manufacture of valuable fertilizer. The importance of fish for this purpose and the extent of the industry in some parts of the country, have recently been well described by Stevenson (1903). Fish refuse is regularly sent from many fish houses in the region to the fertilizer factory at Sandusky, but under present conditions carp contribute very little to this, being shipped almost entirely in the round.

The possible value of the carp as a game fish will be discussed in a later section (p. 619).^a

THE CARP FISHERIES.

Within the past decade the carp fishery has increased to such an extent in the general regions of Lake Erie and the Illinois River that it now forms a recognized and independent industry. Although it

^aThere is one purpose for which the carp would afford valuable opportunity which has not been mentioned—that is, as material for scientific study of variation and heredity among fishes. Experiments in this line have been actively prosecuted in recent years, especially with plants and mammals; but so far as I am aware nothing has been done as yet with a fish. That the carp would be an excellent subject for such experiments is evident from its great variability, its adaptation to domestication and the consequent ease with which it can be reared, its hardiness and rapid growth; and, finally, its great fertility, affording abundant material for quantitative results. Probably the only rival of the carp as a fish for this purpose would be the gold-fish, which might be preferable on account of its smaller size.

is carried on to some extent throughout the entire year, and some persons devote their whole time to it, the bulk of the fishing, in the Lake Erie region, comes in spring and summer, when the number of men engaged is greatly augmented. Many of these persons are professional fishermen who at other seasons are engaged in catching other kinds of fish; but many also are farmers, usually living in the vicinity of the fishing grounds, who supplement the income of their farms in this way. For this reason it is very difficult to estimate the number of men engaged in carp fishing, either for a part or for the whole of their time.

By far the greater number of carp marketed are taken in seines, and the methods differ only in details from those employed in seining generally. For this reason I shall give but a short description of the methods employed, and shall confine my remarks to the fisheries along Lake Erie and the adjacent waters. Apparently about the same methods are employed by the Illinois fishermen. (See illustrations in Illinois fish commissioner's report, 1900-1902.)

Some of the fishermen, especially those who fish along the shores of Lake Erie, make their headquarters in the cities where the wholesale houses are situated, making trips of two or three days, or even a week or more duration along the shores, and running back when they have a load of fish. These trips are made usually in open, flat-bottomed boats, of the style known on the lakes as "seine boats" and "pound boats." They are rigged as single or double "cats," but with the sail extending beyond the gaff to form a sort of permanent topsail. Others, and especially the farmers who fish for only a portion of the year, usually have a permanent camp established near some of the marshes. The fish when caught at these places are transferred at once to live-cars if to be kept but a short time, or to artificial ponds if they are to be kept longer, and are later sent to the wholesale houses either in wagons or by boat.

SEINING.

The seines used in this fishing are commonly 40 to 50 rods in length, about 18 feet deep in the middle and 10 feet deep at the ends. The middle portion or bag is generally about 5 rods long and has a 3-inch mesh, while the wings have a 4-inch mesh. Longer seines—to a length of 80 rods—are sometimes used, but are usually found to be too inconvenient. The cork-line is well supplied with floats to keep it up, but there are usually no weights on the lead-line. The lead-line is made shorter than the cork-line, however, so that it hauls somewhat ahead of the latter and hugs the bottom. The seine boats commonly used are open, flat-bottomed, centerboard boats about 20 to 30 feet long, square at the stern, and fitted with a single mast (fig. 3, pl. II). The seine is loaded into the stern of the boat in such a way that it can be paid off easily, and is taken to a ground where the fishermen have

reason to think there are carp. There are usually certain definite beaches where the hauls are made, places that are known to be comparatively free of vegetation and snags. As the summer advances it becomes more necessary to make the hauls on regular grounds, which are thus kept comparatively free of weeds. Where the seine has not been more or less regularly hauled the weeds become so abundant that it is impossible to make a good seine haul over them, for the lead-line trips and can not be made to hug the bottom. The various hauling grounds are patrolled with considerable regularity, and as soon as the fish come on in any numbers the fishermen are usually aware of it.

For a seine of the size mentioned a crew usually consists of not less than four men, though two crews sometimes help each other haul, thus reducing the labor. Nominally the waters are free for any one to fish in them, but as a matter of fact certain crews come to have a feeling of ownership for the hauling grounds they have established, and in this way they assume rights which are generally respected among themselves by an unwritten law.

Arrived at the hauling grounds, the fishermen proceed with caution, making as little noise as possible, so as not to frighten the fish. A long brail rope is bent to each end of the seine. The free end of one of these is left on shore, where a part of the crew remain as well, and the others row the seine boat out in a big sweep around the hauling ground. First the brail rope is paid out and then the seine itself, and finally the other brail rope is carried to the shore at a considerable distance from the point of starting. One person in a small duck boat usually follows along the seine to see that it sets right, and that it has not caught on any snags. The brail ropes are now passed around the drums of wooden reels or windlasses, and wound slowly in, one man keeping the line taut while one or two others wind in. In the meantime the fisherman in the duck boat follows along the net as it is gradually brought in, watching to see that it does not trip and freeing it if it catches.

When the brails have been brought close into the shallow water the two ends of the seine are carried along shore to some median point, and the net is now pulled in directly, hand over hand. In order to keep the lead-line down to the bottom a "jack" or "roller" is pushed down into the mud, so that the line runs under a sort of wooden spool. In this way the seine is gradually hauled in until all the fish are bunched in a small portion of the bag (figs. 1 and 2, pl. II), from which, with short-handled dip nets, they are either transferred directly to floating wooden crates or live-cars, or are placed in a boat and later transferred to the cars (fig. 3, pl. II.) The seine is then again loaded upon the seine boat, and if another haul is not to be made soon is taken ashore and spread out on a reel to dry.

Under certain conditions special methods of seining are regularly

1. Carp fishing near mouth of Sandusky River.

3. Seine boat and live-car, Sandusky River.

2. Seining carp from pound at Squaw Island, Sandusky River.

4. Preparing carp for smoking, Sandusky, Ohio.

employed. For example, some of the marshes connected with small tributaries of the Sandusky River open into the main channel by outlets so definite that any fish which happen to be in the marshes can be shut off from the river simply by setting a seine across these outlets. As has already been explained (p. 558), on account of the varying direction and force of the winds over Lake Erie the water level is almost constantly changing, affecting also the level of the waters of the bays, rivers, and marshes. By experience the fishermen have learned that when the current sets up and the water level is rising, the carp work up the streams and spread out over the marshes. Conversely, with the fall of the water they move out of the marshes again into the deeper waters. So careful watch is kept of the currents, and shortly after the water has reached its highest, and is beginning to go down again, a seine is stretched across the outlet from the marsh, as described above. A row of stakes is placed in a semicircular line on the downstream side of the seine to prevent its being carried away by the force of the outgoing current, and the cork-line is made fast to each of these stakes, so that the net will not be carried away if the current should change and set upstream again. As the water recedes the carp crowd on the upstream side of the net in large numbers, and when the fishermen decide that enough have come down to justify it, the haul is made. If the current is still running out, a second seine is often set immediately in the place of the first. The fishermen can get some estimate of the number of carp that have gathered above the seine by the number that are seen splashing, or by running a paddle slowly through the water, when, if there are many fish present, they can be felt to bump against the paddle. To make the haul, a brail rope is carried across upstream from one side to the other, and the net is wound in to one shore in the usual way.

An outfit for seine fishing, including seine boat, seine, lines, and other accessories, represents an outlay of about \$150 to \$200. In other words, a capital of \$40 to \$50 each is required where the crew consists of four men. Some crews, consisting, perhaps, of only two or three men, who work on a smaller scale, are probably able to outfit for a smaller sum. In some cases the outfit is furnished by a wholesale dealer or fishing company, and the fishermen work on a salary or on a percentage of the value of the catch.

The time ordinarily required to make a seine haul and dispose of the fish is from one to two hours, though it may vary with conditions, and the haul is not considered to have paid unless at least half a ton of fish is taken. As a rule, the fishermen will not make a haul unless they think there is a chance of getting a greater amount of carp than that. The number of fish which may be taken at one time depends in large part upon the season, and the size of single hauls sometimes made during the spring months is almost incredible. Upon what appeared to be reliable information there were reported to me a num-

ber of hauls in which 10 tons of carp were taken at one time. It would probably be fair to assume that these fish taken in the spring averaged in the neighborhood of 8 pounds each, which would mean that each haul contained some 2,500 fish. The largest single haul of which I heard at Lake Erie was said to have contained 14 tons of fish. A recent apparently well-authenticated report from Lake St. Clair, however, exceeds this by more than as much again. Net fishing in Lake St. Clair has been prohibited by the state of Michigan until within a short time, and in the favorable marshes of the St. Clair delta and about the mouth of the Clinton River the carp had increased to an amazing extent, resulting in some phenomenal hauls now that seining for these fish is permitted. The American Fish Culturist for July, 1904 (vol. 1, no. 7, pp. 18-19), quotes from the Detroit News an account of probably the largest haul on record, and adds further confirmation of the report from Mr. Seymour Bower, superintendent of the Michigan state hatcheries. The article seems of sufficient interest to quote in full:

"That despised fish known as the German carp is having a growing commercial value, and with the possibilities of carp fishing in mind, Carl Schweikart formed two companies, the St. Clair and Erie Carp Company and the Detroit Carp Company. The field of operations is at the mouth of the Clinton River, where the water is clear and the fish are supposed to be at their best. The former company has had phenomenal success in carp catching, having taken in one haul last week 7,200, which they suppose will average about 8 pounds. The catch was made about 8 o'clock in the morning, and several men were kept busy all day getting the carp out of the nets and into the ponds in which the carp are kept until sold. Eastern buyers are figuring for the purchase of their entire catch, but Mr. Schweikart is inclined to wait for better prices. The quotation in New York is now 3 cents a pound.

"What do they do with the carp? Well, they are considered a delicacy by hundreds of patrons of the best hotels and cafés in the East, but the name 'Great Lakes salmon' is preferred."

Referring to the above, Mr. Seymour Bower, superintendent of the Michigan State hatcheries, says:

"The big haul was made in Lake St. Clair, near the mouth of Clinton River. Net fishing of all kinds was prohibited in this lake until the last legislature passed an act allowing the seining of carp. This lake, as you may know, is famous for its small-mouth bass fishing, and it is claimed that the presence of the carp in such overwhelming numbers is bad for the bass; hence the passage of this law."

"Mr. Schweikart is interested in two companies fishing for carp, and I supposed that report of the catch for the month of May, received a few days ago, covered everything in which he was interested, but it was for one company only. The report for the other company was received this morning, and the big haul is there all right. I then called Mr. Schweikart by 'phone and he not only confirms the statement made in the clipping, but says the half was not told, and I know Mr. Schweikart is thoroughly reliable. He states that from the big haul they impounded 7,200 carp by count, and for want of time and facilities for handling were obliged to let fully as many more go, and that the fish taken will average not less than 10 pounds in weight. The two companies in which he is interested impounded 44,900 carp by count in May, or upward of 200 tons.

"Following are the rules under which eleven firms are now fishing there:

"RULE I.

"No person shall catch German carp in any manner except with hook and line, without first notifying in writing the State game warden and the State Board of Fish Commissioners, at their office in the city of Detroit, of the time and place where he intends to fish for carp.

"RULE II.

"No person shall catch or take German carp from said waters except with a seine with a four-inch mesh extension measure as used, and with a hook and line. No person shall catch or take German carp with a seine without first giving a good and sufficient bond conditioned for the faithful observance of these regulations and for the payment of a penalty of fifty dollars (\$50) for each and every violation of these rules and regulations.

"RULE III.

"If German carp which are caught are to be kept for future sale, shipment, or delivery, a pond or other suitable inclosure shall be prepared in which said carp shall be placed and kept, and the State game warden and the State Board of Fish Commissioners shall be forthwith notified in writing of the location of such pond or inclosure. Said pond or inclosure shall at all times be open to the inspection of the said game warden, or any of his deputies, and to the inspection of the State Board of Fish Commissioners, or to the inspection of any person appointed by said board for the purpose of inspecting said carp and the manner of fishing therefor.

"RULE IV.

"When any such German carp are killed and sold, shipped, or delivered, the owner or shipper shall make duplicate invoices of the same, one of which shall forthwith be delivered or mailed to the State game warden, or to such person and to such place as he may designate, and the other shall accompany the package of carp so sold, shipped, or delivered. Said invoice shall truly state the time and manner of shipment; by and to whom consigned, sold, or delivered. Every fisherman who shall engage in business of catching German carp shall once a month make a report to the State Board of Fish Commissioners, which report shall contain a true statement of the quantity in pounds of the daily catch of German carp made by him during the month. Said report shall be mailed or delivered as aforesaid on or before the fifth day of each month.

"RULE V.

"Every package of German carp sold, shipped, or delivered shall be plainly marked so as to show what it contains. It shall also show by whom same is sold, shipped, or delivered, and such package shall contain no other kind of fish whatever.

"RULE VI.

"When any other kind of fish than German carp shall be caught or taken in the seine prescribed by law and by these regulations, the same shall be carefully put back in the water and, under no circumstances, kept by the fisherman.

"RULE VII.

"Whenever a special inspector shall be required to watch the taking, killing, or shipping of German carp by any fisherman, the expenses of said inspector, not exceeding three dollars per day, shall be borne by such fisherman.

"The right to amend and alter these regulations at any time is especially reserved by the State Board of Fish Commissioners, and will for each violation of any of the laws of Michigan with reference to the protection of fish, pay to the State Board of Fish Commissioners the sum of \$50, then this obligation is to be void, otherwise to remain in full force."

The laws governing the taking of carp in Lake St. Clair are quoted to show what can be done in cases of this kind to allow of the utilization of the carp, to decrease their numbers, if that seems necessary, and still to afford protection to the native fish, especially the game fish, such as the black bass.

OTHER METHODS OF CAPTURE.

The number of carp taken by other means is insignificant as compared with that taken by seining—in fact, it is seldom that any other kind of net is set exclusively for carp. Small numbers are taken more or less regularly in the pound nets set in Lake Erie for saugers and pickerel (wall-eyed pike) and for white-fish, as well as in the traps and fyke nets set in the bays and rivers for other species of fish. A few carp—mostly small ones—are obtained in the gill nets set for white-fish about the Bass Islands in the fall. Occasionally when a number of carp have entered some place where a net can be set across their only way of escape, or where they can be driven into it, a gill net is used. Thus if carp are frightened out of the rushes where they are feeding they will usually make directly for deeper water. If a gill net is set so as to intercept them many will rush into it and become entangled; but they are such vigorous fish that unless the net is an exceptionally strong one they are apt simply to tear it to pieces. I believe trammel nets have been tried in the same way, but not with enough success to warrant their general use.

PACKING AND SHIPMENT.

The method of transportation of the fish to the fish houses has already been mentioned (p. 611). The fishermen may dispose of them immediately after they are caught, or they may keep them for a time pending a rise in the market price. In the latter case the carp are retained in pens or ponds as will be described later. The fish are received at the wholesale houses often in a living condition, although they may have come a distance of several miles packed a foot or two deep in a wagon or boat. They are transferred from the boats to boxes by means of short-handled dip nets, the iron frames of which are usually straight on the side opposite the handle, a construction which facilitates using them to take fish from the bottom of a boat. The boxes are now slid inside the fish house and placed on the scales where the fish are “weighed in,” and are then dumped out in a pile on the floor. Usually no record is made of the number of fish, but all measurements are by weight. As soon as possible the fish are packed into plain lumber shipping boxes of uniform size and especially made for this purpose. A box is placed on the scales and chopped ice is shoveled in until it tips a certain weight; a 150-pound weight is then added, and carp are shoveled in until it is balanced. For handling the

fish when they are on the floor ordinary large scoop-shovels are used. Each day the boxes of carp are shipped either by freight or express to the large cities, where they are in demand. From the fact that some of the fish from Lake Erie at times reach New York still in a living condition, it will be seen that there is no need that the fish should be cleaned before shipment, even did not the consumption of the greater portion by Jews demand that they be shipped "in the round."

Some firms, when the supply of carp exceeds the demand at the time, freeze a part of the catch and hold them over in this way, but the frozen fish do not find so ready a sale.

EXTENT OF THE FISHERIES.

The amount and value of the carp output of Lake Erie has been steadily on the increase for the past eight or nine years. The fish first began to be handled by the dealers in about 1890 or 1891, but had no extensive market until about 1895. At a fish house in Port Clinton it was stated that when they first began to be taken they were thrown in with the mullets and sold at 1 cent a pound, and the dealers did not want them at that price. They were then put on the list as German carp, at 3 cents, and at once found a ready sale.

That the fishery had not become established in 1892 is shown by the fact that carp are not mentioned under the "Products of Lake Erie fisheries," in the Report of the United States Fish Commission for that year (p. cl), nor in the paper by Smith in the same report on the fisheries of the Great Lakes.^a They were being used more or less in other places, however, and Smith (1898, p. 494) estimates the amount of carp taken in the waters of the United States, exclusive of the Great Lakes, in 1894, as 1,448,217 pounds, valued at \$37,683. The catch from Illinois was more than four times that from any other state, Iowa coming next. The Lake Erie fisheries had increased enormously by 1899, and Townsend (1901) in reporting for that year says (p. 178):

The catch of carp in Lake Erie in 1899 amounted to 3,633,679 pounds, valued at \$51,456. The report of the Illinois Fishermen's Association shows that the catch of carp in the Illinois River is greater than that of all other species combined, the quantity of carp taken in 1899 amounting to 6,332,990 pounds, valued at \$189,980. The yield of carp from the Ohio River and two of its tributaries, the Cumberland and Wabash rivers, during the same year, amounted to 113,387 pounds, worth \$6,654.

These figures show an increase in the quantity of carp derived from the above-named waters amounting to nearly nine times the quantity yielded six years ago.

^a Although the Lake Erie and Illinois carp fisheries had not become established at this time, these fish from eastern waters were finding a ready sale in the New York markets. This is shown by the following statement of Mr. John H. Brakeley (1889a): "I have sold several hundred pounds of carp during the past autumn in the New York market, the commission merchants getting 15 cents a pound for them. I am satisfied that it will pay to feed carp, and shall do considerable of it next season."

In the summer of 1901 I myself visited all the principal fish dealers on Lake Erie, and made as accurate an estimate as possible of the extent of the carp fishery for the calendar year 1900. A number of factors prevent great accuracy in such an inquiry; for example: (a) Some dealers keep no record whatever of the carp handled by them; (b) others keep record only of their own catch, not recording those bought by them from fishermen; (c) in some cases the carp are weighed in and sold with the suckers, and (d) it sometimes happens in the spring that carp come in faster than they can be handled, when the surplus is weighed up with the refuse, and sent to the fertilizer factories. In spite of this, however, it is felt that the following statistics give a fair estimate of the total amount of carp shipped from Lake Erie in 1900:

	Pounds.
Detroit, Mich	300, 000
Monroe, Mich	14, 000
Toledo, Ohio	432, 548
Port Clinton, Ohio	2, 361, 723
Sandusky, Ohio	1, 260, 817
Total for western end of lake	<u>4, 369, 088</u>
Huron, Ohio	14, 168
Vermilion, Ohio	3, 561
Lorain, Ohio	20, 773
Cleveland, Ohio	16, 000
Ashtabula, Ohio	2, 500
Erie, Pa	12, 000
Buffalo, N. Y	160, 000
Total for eastern end of lake	<u>229, 002</u>
Total for lake	<u>4, 598, 090</u>

The price paid to fishermen for carp varies from about 30 cents per 100 pounds in the spring months to 2½ cents per pound in the winter. Taking 1½ cents per pound as a fair average, the value of the carp catch of 1900 would be \$68,971.35. This is an increase of 964,393 pounds over the catch of 1899, and an increase of valuation of over \$17,000. As nearly as could be judged at the time, the catch for 1901 promised to be about as much larger than that of 1900. No accurate statistics have been gathered since that time, but the fishermen say that the fishery is still increasing.

The number of pounds of carp taken in Lake Erie in 1899 equaled nearly one-sixteenth of the total catch of fish of all kinds in the lake for that year, while the value was about one twenty-second of the entire fisheries product.

In the Mississippi River and the streams tributary to it, especially in the Illinois River, the carp fisheries are of far greater comparative importance, and for several years carp have constituted over one-half of the total yield of the fisheries of the last-named stream (Townsend,

1902, p. 159). In 1899 the catch for these streams was 11,369,340 pounds, valued at \$259,252. In a letter dated October 19, 1903, Dr. S. P. Bartlett states that the value of the output in 1901 from the Illinois River was nearly two-thirds of a million dollars, 17,000,000 pounds being the output;^a and in a previous letter—

I am safe in saying that of all the fish produced in our inland waters and rivers the carp will bring the fishermen more money than all their other catch.

ANGLING.

The anglers for trout and bass naturally look upon the carp with great contempt. Nevertheless there are those who are ready to champion the foreigner, and some would even rank him as a game fish. In Germany, angling for carp in the open waters has afforded recreation, and has been a not unimportant factor in the food supply of the people; and in England carp have been sought by the angler since their earliest introduction into that country. They are mentioned among the fishes included in the treatise on angling in the "Booke of St. Albans," first published in 1486, and consisting of a number of compilations often attributed to Dame Juliana Barnes (or Berners), though the section on angling was probably not written by her. This account is interesting as being probably the earliest record we have of the carp in the English language; and being brief, may well be quoted here:

The carpe is a deyntous fische: but there ben but fewe in Englonde. And therefore I wryte the laase of hym. He is an engyl fische to take. For he is so strange enarmyd in the mowthe that there maye noo weke harness noble fyng. And as touchynge his baytes I hane but lytyl knowlege of it. And we were hald to wryte more than I knowe & hane prouyd. But well I wote that the raffe, worpe & the menow ben good baytes for hym at all tymes as I hane herde saye of peresone credible & also found wryten in bokes of credence.^b

In the later English writings on fishing, the carp is accorded a prominent place, and Izaak Walton (1901 ed.) devotes a chapter to its natural history and the modes of capture. He styles it "the queen of rivers: a stately, a good, and a very subtille fish," and says (p. 17):

And my first direction is, that if you will fish for a Carp, you must put on a very large measure of patience, especially to fish for a River Carp. I have known a very good fisher angle diligently four or six hours in a day for three or four days together, for a River Carp, and not have a bite.

^a It would seem that Doctor Bartlett has put the valuation rather high. Two-thirds of a million dollars for 17,000,000 pounds of fish would mean a value of nearly three dollars per pound. At the same rate used in estimating the value of the Lake Erie catch above, it gives the Illinois River catch for 1901 would be worth \$259,252. If we estimate the Lake Erie catch for 1901 on the basis of the catch of 1900 over that of 1899, an increase of nearly a third, it would amount to approximately 5,800,000 pounds with a value of \$67,000, making a total of 1,239,252 pounds worth \$259,252 for the two regions. There are no data at hand for estimating the amount of carp caught in other parts of the United States, but this probably comparatively small in proportion to that of the regions given.

^b From a reprint of the Wynkyn de Worde edition of 1486 London, 1616, under the title "Fishing with an angle," signature f. 1j.

He then goes on to tell when one should fish, the kinds of bait that should be used, and ends with an elaborate recipe for its cooking.

Perhaps the best directions for fishing for carp with hook and line are those quoted from Pennell by Goode (1888, p. 414) in his popular treatise on American Fishes.

Early in the morning, and, occasionally, late in the evening, are the best times for fishing; but, as observed, the catching of Carp with the rod and line is always a difficult and uncertain operation, particularly if the fish are large. The smaller the pond, the better the chance I have always found of catching Carp and Tench, though, of course, they are not so large as in bigger waters. I once caught a bucketful of Carp before breakfast, in a pond by the side of a road between Weybridge and Byfleet, which was not bigger than an ordinary sized ball-room. The biggest of these Carp did not, however, exceed 2 pounds in weight.

The following is the method of Carp fishing in stagnant waters which I have found most successful:

Let the line be entirely of medium sized or fine round gut—clouded, if possible—with a very light quill float, say No. 4, and one good-sized shot, about 6 inches or so from the hook, which should be No. 5 or 6 and baited with a brandling or red worm. Plumb the depth accurately; and arrange the distance between the float and the shot, so that the latter may exactly rest on the bottom, weighing down the point of the float to about “half-cock,” and letting the gut below the shot and the bait lie on ground. Fix the rod in the bank and keep perfectly quiet. When a bite is perceived, do not strike until the float begins to move away.

It constantly happens, however, that the Carp will not be taken either by this or any other mode of fishing with which I am acquainted; but if he is to be caught at all it is thus.

The baits are, worms (first), gentles, greaves, grains and various sorts of pastes, of which latter, however, I believe the plain white bread crumb paste is the best, as well as the most easily made. Professor Owen, who had a good deal of Carp fishing experience in Virginia water, gave me the results of his practice which concur in a great measure with my own, except that he fished with his bait paste made of soft herring roe worked up with bread crumbs and wool, a favorable substitute sometimes for the brandling.

In Germany the “angler usually prepares for his sport by ‘ground-baiting’ with a thousand or more angle-worms, twenty-four hours before he expects to fish, and while fishing he throws worms into the water.”

While most of our sportsmen would probably indignantly object to having the carp classed as a game fish, it must be admitted that whether it should be so classed or not depends largely upon our definition of a game fish, and, as Goode says (1888, p. xiv), “no fish which is not of the highest rank as a table delicacy is rated by Americans as a game fish.” He continues:

The barbel, the dace, and the roach, the pets of the father of angling, classical in the pages of sportsmen’s literature, are despised by new world authorities, and are now considered “coarse fish” even by English writers. Yet they afford excellent sport—sport which in England tens of thousands enjoy to every one who gets the chance to whip a salmon or trout line over preserved waters.

And so it is with the carp. Those who live where there is an abundance of other fish, such as bass and pickerel, or even of perch and

breem, will probably not abandon those fish for the pursuit of the carp, while, on the other hand, those who have done most of their fishing for buffalo, red-horse, mullet, or bull heads should welcome the carp with joy. How far in this country its capture is supplanting, or at least supplementing, the other of the coarser fishes in this respect has been best told by Dr. S. P. Bartlett (1903), of Illinois. For this reason I quote the greater portion of his paper:

The question has been asked me a great many times why it was that carp can not be taken with the hook and line. A great many persons have told me that they have used all kinds of bait and failed to get them to take it. These inquiries came to me as a surprise from the fact that hundreds daily fish for carp with hook and line on Quincy Bay and all along the Illinois River with great success.

I have found the best bait to be a dough ball made by boiling cornmeal to a good stiff mush, and then working the ordinary cotton batting into it until it becomes hard and stiff, and then rolling into little round pellets about the size of a marble. Bait prepared in this way will not be easily dissolved by the water. I use the ordinary Carlisle hook fastened on the end of a good strong line and three or four inches above the hook, attach quite a heavy sinker which will take the line to the bottom and allow the bait to flow up away from the bottom. Another good bait is the ordinary ship stuff from the mills, boiled stiff and dough rolled out in sheets and then cut up into little squares, perhaps three-fourths of an inch square. Fried potatoes, sliced raw and fried until they become stiff, not brittle, also is a fine bait. Anyone conversant with the hook and line at all, will have no trouble in carp if this bait is used as indicated.

On Quincy Bay I have seen as many as two hundred people fishing for carp along the shores, and nearly all of them get good fair strings. The carp when hooked is a very vigorous fighter, and care must be used that he does not break the hook or break out the hook from his mouth. I would advise the use of the landing net. They are daily taken on trout lines, using the same kind of bait.

Since your request for information as to the carp from an angling standpoint, I have given the matter a great deal of attention, and have been greatly surprised at the extent to which carp are caught with hook and line. From Cairo to Dubuque on the Mississippi River I have found shores at all the towns lined with people fishing for carp, all catching them. One day last week, from the lower end of Peoria, Illinois river, to water works point, a distance of three miles, I counted 1,103 people fishing with hook and line, and on investigation [it] developed that a large per cent of them were taking carp. The majority of those caught weighed a pound and as heavy as five pounds, all of them probably used as food. Permit me to introduce here a letter from one of the best known sportsmen in the State [Mr. M. D. Hurley, of Peoria, Ill.]:

"Carp fishing with hook and line has now taken its place with bass and other kinds of fishing. All along the river in this locality carp are being caught freely with hook and line this year, and to say they are gamey, is not half expressing it. For the past month I have made it my business to go along the river and take notes of this particular kind of fishing and talked with no less than 25 different persons who were busy catching carp, and in every instance I was told it was rare sport to hook a carp, as it was quite as much of a trick to land one as it was to land a bass; dip nets were used generally to land the carp, as the activity of the fish when jerked out of the water would tear the gills and free the fish quite often. The bait used when fishing for carp is dough balls and partly boiled potatoes, the latter being best in the opinion of the majority. The carp will bite on worms quite freely also, and in two instances, I found carp had been taken with minnows, something that has been considered impossible heretofore, but in these two cases I am certain it was

done, as I have the names of the parties who caught the fish. An old German who lives here goes daily to the river with a regular fly casting pole and reel to fish for carp. Of course he exchanges the fly for the regulation hook, but he used his reel in landing the carp, and says there is no finer sport than fishing for carp. This man uses partly boiled potatoes altogether and is very successful in taking carp in numbers daily. I have caught a great many carp myself with hook and line, using potatoes, dough balls and worms, and found that the partly boiled potatoes worked best, as the carp seemed to take that particular bait when they would not bite any other. As for the sport of catching carp with hook and line, I consider it equal to anything in the way of pleasure fishing, as the fish is gamey and will fight as hard against being landed as bass or other game fish and is to be handled with precaution on account of the tender gills, which will often tear when hooked by an inexperienced angler. In the past two years carp have become popular where they were unpopular, because of the wearing away of the prejudice that they were of no benefit to the angler on account of the belief that they would not take a hook. Now it is different, as the very ones who were so loud in their protest against the carp, have found great sport in taking them with hook and line, and it is wonderful to hear the change of sentiment as to the carp for food purposes. They are a good fish now and fit for a king in comparison to what was said of them while the prejudice still existed. To my mind the carp is a good fish for food purposes and is fast finding favor in the west in every way, now that the angler has found it is the coming fish for sport. Just at present, in the Illinois river, we have a world of all kinds of game fish and no end of carp, which insures the angler his full measure of sport until the end of time."

At Detroit and at Put-in Bay I have seen numbers of persons fishing from the wharves with hand lines for carp. The bait in most general use was a piece of boiled potato wrapped in mosquito netting to keep it on the hook. On the 25th of July, 1901, with this bait, I saw taken from the steamboat wharf at Put-in Bay a carp which measured 31.5 inches in length and the weight of which was estimated at about 16 pounds. This fish made a vigorous fight, and would have taxed the ingenuity of an expert angler if he had hooked it on a trout line and a light rod.

There is a tendency among sportsmen to deny the title of game fish to any that will not rise to a bait, either real or artificial. In such a category the carp certainly can not be included; it must be classed rather with those fishes that reward the quiet, "contemplative" angler, who must wait patiently until the fish bites, but who then has the same problem and must exercise the same skill in landing his game that he would have to display had he hooked one of those species generally acknowledged to be game fishes.

CARP CULTURE.

Carp ponds and pens may be divided primarily into classes according to the purposes for which they are used: (1) Permanent ponds or complements of ponds, used for breeding, rearing, and retaining the fish until such time as they are large enough to dispose of in the market; and (2) temporary ponds or other inclosures, used only for holding carp from times when they are easily obtained until, on

account of their scarcity, the market value has risen to a point making their sale profitable. The terms permanent and temporary are thus used here, as it will be observed, not in the sense of the time of duration of the ponds, but as denoting the manner in which they are used. The latter sort correspond more or less closely in their function to the stock ponds on a well-equipped German carp farm. Either sort may be natural or artificial.

PERMANENT PONDS.

With a few possible exceptions carp culture has never been attempted in this country after the lines on which it is carried on so extensively in Germany. Most of those persons throughout the United States who aspired to carp culture at the time these fish were being distributed by the Government merely dumped the fish into any body of water that was convenient, or into any pond that could be hastily scraped out or constructed by damming some small stream, and thereafter left them to shift for themselves, possibly feeding them occasionally at first. That such efforts were not a success is no more to be wondered at than would be a man's failure if he attempted to establish a successful poultry farm merely by turning a few dozen fowls loose in the neighborhood of his home. Whether extensive and properly conducted carp farms would then, or would now, be profitable and pay a reasonable return on the capital and labor invested, is another matter, and will be considered a little farther on.

It is not proposed here to enter into an elaborate description of the methods employed by the successful European carp culturist. American readers who may be interested in the subject are referred to the excellent paper by Hessel (1881), which has been cited frequently throughout this report, and to the fuller account given in the translation published by the United States Fish Commission of the work by Nicklas (1886). Numerous works on the subject have been published in German, and references to them will be found in the bulletins named above; among the more recent books may be mentioned those by Susta (1888) and Knauthe (1901).

Some idea of the extent to which carp culture is practiced in Germany and the neighboring parts of Europe may be gained from the following extract quoted from Hessel (1881, p. 866):

A celebrated establishment for carp-culture, with large, extensive ponds, was located, as early as the fourteenth century, near the town of Wittingau, in Bohemia, Austria. The first beginning of it may be traced back to the year 1367. At that time the lords of Rosenberg called into existence and maintained for centuries these establishments on a scale so extensive that to this day they are the admiration of the visitor, the main parts having survived, while the race of the Rosenbergs has long been extinct.

The manor of Wittingau suffered greatly from the calamities of the Thirty Years' War, and with it, in consequence, its fish-culture. The latter only recovered the

effects of it after passing, together with the large estate of a rich monastery of the same name, in the year 1670, into possession of the Princes of Schwarzenberg, their present owners. The extent which carp-culture has reached on these princely domains will be seen from the circumstance that their artificial ponds comprise an area of no less than 20,000 acres. The proceeds amount to about 500,000 pounds of carp per annum. The ponds of the Princes of Schwarzenberg are probably the most extensive of the kind on the globe. They are usually situated in some undulating lowland country, where small valleys have been closed in by gigantic dams for the purpose of forming reservoirs. Similar establishments, though not equally extensive, are found in the provinces of Silesia and Brandenburg; as, for instance, near Breslau and Cottbus, in Peitz and Pleitz, which I visited last year. In Hesse-Cassel, Hanover, Oldenburg, Mecklenburg, and Holstein there are also many hundreds of ponds, none of them covering more than a few acres, but almost every large farm possessing at least one of them.

The well-appointed carp-cultural establishment has at least three kinds of ponds, each adapted for a particular phase of the industry. These ponds are usually made by throwing dams across small valleys, and by the aid of dikes, and are commonly fed by small streams flowing into them, by springs, or they may depend entirely upon the rains to keep them filled. These last are often spoken of as "sky-ponds," and are much more uncertain than the others. The ponds fed by streams are ordinarily protected from flooding by freshets by leading the main channel of the stream around them, so that the amount of water which flows into the pond can be regulated at will.

The classes of ponds are:

1. Spawning ponds. Shallow ponds in which the water is easily warmed by the sun, and suitable for the spawning fish.

2. Raising ponds. Ponds, usually of medium size, to which the fry are transferred and where they are retained, isolated from the larger fish, until they are a year or two old.

3. Stock ponds. Large ponds in which the fish are kept until they have reached a marketable size; this is usually considered to be when they have reached a weight of $2\frac{1}{4}$ to $2\frac{1}{2}$ pounds. One reason that the young fish are reared for a time in the raising ponds is that in the stock ponds with the older carp are often kept a number of predaceous fish, such as perch, pike, etc., which are supposed to keep the carp in better condition by preventing them from becoming too lazy and sedentary. These fish would destroy the carp fry if the latter were put into the stock ponds while still small. The predaceous fish also form a secondary source of income.

Since the stock ponds are not always favorable for the wintering of the fish there are sometimes ponds especially adapted for this, and these are known as—

4. Winter ponds. These should be in sheltered localities, if possible, and should have a depth of at least 6 to 8 feet.

All the above classes of ponds are constructed upon the same general principle. Ditches from the various parts of the pond lead into other

ditches which are deeper, and these finally lead into a still deeper pit (the "fish pit"), which is situated at the place of outlet, usually near the dam. When it is desired to drain the pond, the water is drawn off gradually, the fish work down into the ditches, which completely drain the pond, and so they all come finally into the fish pit, whence they can be taken with nets. In a properly constructed pond it is possible to draw all the water from the pit, and thus completely drain the pond. It is common on many farms to have a curious "rotation of crops;" the fish ponds are drained and turned to agricultural purposes for a season or two, when by closing the outlet gates and allowing the water to fill them again they are reconverted into ponds, and pisciculture is resumed. Such a proceeding is said to have a salutary effect upon both industries.

TEMPORARY PONDS AND PENS.

Although there are very few, if any, carp-cultural establishments in this country conducted on the principles of those that have just been described, there is, nevertheless, an increasing number of ponds being constructed and used for the temporary retention of the fish. This is true especially in the Lake Erie district. These inclosures vary all the way from the simplest pens, not calculated to hold more than one-half ton to a ton of carp, to extensive ponds covering large areas and constructed and maintained at a considerable expense.

These temporary inclosures may again be divided into two classes: (1) Those in which the level of the water is not under control, but varies with the changing level of the surrounding waters; and (2) those in which the water level in the ponds can be artificially maintained at any desired height.

Under the first class the simplest kind is that already mentioned (p. 612) as being used when it is desired to retain the fish only a very short time—a few days to a week or so at most. These are the ordinary live-cars or crates—large boxes constructed of rough boards with cracks between, which allow the access of plenty of fresh water. When the fish have been placed in these, the covers are fastened down and the cars towed out to where the water is deep and certain to be fresh—well out in a stream, if possible. The cars are weighted with heavy stones, so that they float with their tops just at the surface of the water. Fish kept in cars are seldom fed, unless it is necessary to keep them much longer than is usually the case. When they are taken out, dip nets are employed.

A common method of constructing inclosures which will accommodate a larger number of fish, and in which they may be kept indefinitely, is to build out into a stream, or from the shore of a bay or lake where the conditions are suitable, a sort of rough picket fence around three sides of an area, the shore usually forming the fourth

boundary (fig. 2, pl. II).^a This fence consists of rough boards driven into the mud a short distance apart, and supported at intervals by strong stakes driven firmly into the bottom. It is necessary to have the top of the fence several feet higher than the highest water, to prevent the fish from leaping out. A woven-wire netting 2 to 3 feet high is often added to the top of the fence for this purpose; it is not practicable to use the wire netting under the water, as the fish would become badly bruised in attempting to get through it, or by dashing into it without seeing it. The pens may be of any size, from small ones, which will accommodate only one or two hundred fish, to those covering an extent of some 2 or 3 acres. Larger ones than this are probably not practicable on account of the difficulty that would ensue in attempting to get the fish out of them; obviously the water can not be drawn off and the pen drained, so the only way of taking the fish is with a seine. This is done by setting the seine around the perimeter of the area, close to the fence, and then hauling it to one corner of the inclosure, where the fish can be gathered into the bag of the seine (fig. 2, pl. II).

As a rule there is not enough natural food in these pens for the sustenance of the fish, and in order to keep them from falling away greatly in weight it is necessary to supply them with food. The necessity of removing the fish with a seine makes it impracticable to build the pens where there is plenty of vegetation to supply the fish with natural food, since much vegetation would interfere greatly with the seining.

Pens should be built in places sheltered as much as possible from storms, for the high waves are apt to break down the fence and allow the fish to escape. Unusually high water and severe storms caused great damage in this way in Sandusky Bay and vicinity in the summer of 1902, one pen, in which there were said to be 40 tons of carp at the time, being broken down in places so that all the fish were lost.

Portions of marsh which have comparatively narrow openings leading into them are sometimes converted into ponds by throwing embankments, or more often building board stockades, across the narrow places. Such ponds usually have the advantage of containing plenty of natural food, but trouble usually arises when it comes time to take the fish out, as the places are not adapted to the use of a seine. In some cases the embankment or fence, with a convenient gateway, is constructed early in the spring and the gateway is left open until a large number of fish have entered the shallow water of the inclosure for the purpose of spawning, after which the gateway is closed and the fish are entrapped, to be seined out at leisure. At one or two places great areas of marsh were cut off in this way and the fish were prevented from returning to the larger open waters; but this was of

^a A photograph of a carp pen similar to this is shown in the Illinois fish commissioner's report for 1900-1902.

little avail, since the places were so large and the conditions so varied that it was practically impossible to get the fish out.

There remain still to be considered those ponds in which the water can be maintained at a definite height irrespective of the varying level of the neighboring waters. Under suitable conditions they could probably be constructed best in valleys and natural depressions according to the plans already outlined as being in general use in carp-cultural establishments. Under the conditions of our fisheries, however, it is a matter of great economic importance that these ponds should be as near to the fishing grounds as possible, and as the land there is low and marshy the ponds must for convenience be constructed in or along these marshes. For this reason the problems presented are very different from those met with in the building of ponds on higher ground. The greatest difficulty comes, of course, in the matter of the drainage of the pond, since its deepest portions of necessity lie below the level of the outside waters. An idea of the methods that have been devised can probably best be conveyed by giving brief descriptions of two or three ponds which have now been in use for several years.

Along the marshy shore of the Portage River, a mile or two above Port Clinton, Ohio, is a successful carp pond covering some 30 to 35 acres, and owned and managed by two brothers, who also conduct at the same time a fruit farm immediately adjacent to the pond. The site of the pond was originally a marsh, flooded by backwater from the river, where the carp commonly came in to feed and to spawn. It was first converted into a pond (see diagram, p. 628) by throwing up an embankment along the river side, cutting it off from the river, but still leaving it connected by an open gateway protected by a screen or grating. The inclosed water was at the same level as the outside water, and as the level rose and fell a stream rushed in and out through the gateway. This plan was found to be unsatisfactory, as the impounded fish crowded about the grating, neglecting to feed, and at the same time becoming badly bruised by their contact with the bars. The embankment was then raised and the gateway closed, so that the water in the pond could be maintained at a level 1 to 2 or 3 feet or so higher than the mean level of the river, while at the same time the increased height of the water caused it to spread farther back over the land, enlarging the pond, and encroaching upon a neighboring cornfield, a large portion of which was thus converted into marsh. The principal embankment was easily raised by having a shovel-dredge make a cut along the inner side, the excavated mud being deposited on the outer side of the cut to form the embankment. The lower portions were built with a scraper at a time when the river was especially low, at which periods the pond can be practically drained of water. During rainy seasons springs kept the water well up to the desired

level, but during drier times these were not sufficient, and it became necessary to pump water in from outside. This was done for a season or so by means of an "elevator" in a wooden trough or chute in which run endless-chain belts with closely fitting boards forming a series of buckets as they move upward through the trough. (See fig. 2, pl. III.) The motive power at first was a span of horses, but later a 7-horsepower gasoline engine was installed, which does the "pumping" or elevating much more expeditiously. The amount of pumping required to keep the water at the proper height and sufficiently fresh

R i v e r

Diagrammatic plan of carp pond near Port Clinton, Ohio: *a*, embankment; *b*, dam; *c*, engine-house; *d*, water elevator; *e*, chute through which fish are slid into pond; *f*, chute through which fresh water enters pond; *g*, dredge-cut; *h*, outlet. The figures indicate depth of water.

depends very closely upon the weather conditions and to some extent upon the number of fish in the pond. It is seldom that so much as two or three hours a day is required.

The water in the dredge cut is about 12 feet deep, but in other portions of the pond there are few places more than 5 or 6 feet in depth, and much of the water is considerably shallower. In all the shallower parts is a rank growth of aquatic vegetation (sweet flag, cat-tails, deer's tongue, wild rice, bulrushes, burr reed, etc.) which supplies so much natural food that the fish are seldom or never fed artificially. With the maintenance of the water level, thus avoiding the rushing of the water in and out through a grating, the fish remain distributed most of the time throughout the marshy parts of the pond

1. Dam and engine house of a carp pond at Port Clinton, Ohio. Carp are slid into the pond from the chute on the left; fresh water is received from the chute on the right, which comes through the engine house.

2. Outer side of dam, showing engine house and elevator in operation. Same pond as in figure 1.

3. Supplementary engine and elevator for carrying water from dredge cut to pond, Monroe, Mich.

4. Carp in pond at Port Clinton, Ohio, coming up to inflowing stream of fresh water.

where food is abundant. An exception to this is when a stream of water is pumped in steadily for a time; then the fish begin to come from distant parts of the pond to the place of the incoming stream, as has already been described (p. 560). This tendency of the carp to gather around the place where the fresh water comes in is taken advantage of when it is desired to seine them out, the net being hauled in the dredge cut when the fish have congregated there.

Another pond, near the Raisin River, below Monroe, Mich., and but a short distance from Lake Erie, differs in some ways in method of

Diagrammatic plan of carp pond near Monroe, Mich.: *a*, outer embankment; *b*, dam; *c*, engine house; *d*, *d'*, water elevators; *e*, inner embankment; *f*, chute arranged for carrying water either into dredge cut (*g*) or into central area (*k*); *g*, circular dredge cut; *h*, outlets; *i*, dredge cut from river; *j*, outside dredge cut; *k*, central area (water 1 to 2 feet deep); *l*, marsh (barely covered with water).

construction from the one just described, and for this reason seems worthy of mention. (See fig. above.) This pond is smaller than the other, and is of interest as showing how a pond can easily be built in the middle of an extensive flat marsh. This was done by starting with a dredge at the river and cutting a channel straight into the marsh for a short distance. A large circle was then made, the greater part of the mud brought up being placed on the outer side of the cut, thus forming a high embankment, while on the inner side a smaller one was built up, in which, however, several breaks were left. After it had completed the circle the dredge was taken back outside and a short cut was made on the outside and parallel to the outer embankment. When a dam had now been built at the only opening, it was possible to raise

the water in the interior to a height of 2 or 3 feet above that in the surrounding marsh. This was here accomplished in the same way as at Port Clinton, except that steam power was used for the purpose instead of gasoline engines.

The pond then consists of a ditch 7 to 10 feet deep around the entire circumference, the water over the central area having a rather uniform depth of 1 to 2 or 3 feet. The fresh water that was pumped in was originally turned immediately into the circumferential ditch, or could be carried by a wooden flume over into the central area. The first year the pond was used there was found to be great mortality among the fish, a condition probably due to the large amount of freshly exposed soil with which the water came in contact, so that it became charged with humic acid and other products of organic decay until it was unfit for the fish. This condition continued in spite of the fact that fresh water was continually pumped in, especially during the warmer weather, and it was found later that the water at the bottom of the ditch was very foul and with a bad odor. In the succeeding year flumes were arranged so that the fresh water was carried at once to the bottom of the ditch, and the conditions were found to be much improved. There would probably have been less danger in any case during the second year, as the soil had undoubtedly by that time become very well leached out.

Here, as in the pond previously described, it was found that the fish gathered around the stream of incoming water, and here also advantage was taken of this fact in capturing them. The pond could be drained, if necessary, by changing the elevator over to the inner side of the embankment and discharging the water from the pond back into the surrounding marsh.

There is one other style of pond in use in this region that should be mentioned, in order to make the present account complete. These have been constructed especially by the farmers along the southern shore of Sandusky Bay. They are situated on higher ground than those ponds which have just been described, ground that is usually at least a few feet above the mean level of the bay, and are formed simply by scraping the soil out of an area covering usually not over one-fourth to one-half acre, the soil that is removed being used to build the embankments. The water is supplied by windmills or, in a number of cases, by artesian wells. This water would seem not to be well adapted to carp ponds, being cold and strongly mineral, with a very decided sulphurous taste; and yet the carp are said to do very well in it. As the ponds contain practically no natural food supply, the fish have to be fed regularly to keep them from falling away greatly in weight. For this purpose a variety of things are used, but shelled corn is probably employed more than anything else. In one such pond, which contained about 10 tons of fish, the carp were said to have been fed

very largely upon sowed corn, which was cut when about 1 to 2 feet high and thrown into the pond. The proprietors claimed that the fish would dispose of a load—supposedly a wagonload—of this in four or five days. At this same place the first year the pond was used the fish were not fed at all, and when marketed there was only half the weight of fish that had been put in.

THE VALUE OF CARP PONDS.

It is safe to say that under existing conditions, where at certain seasons of the year three or four men with a seine can obtain adult carp in almost limitless numbers with comparatively little trouble, carp culture in the ordinary sense would not be profitable. At least this is true in regions such as Lake Erie and Lake St. Clair, where carp are so abundant. That regular culture ponds, in which the fish are reared from the egg until of a saleable size, could not be conducted with profit in proximity to some of the large cities which constitute the principal markets for carp is not so certain. Undoubtedly, as the demand for carp grows, as it surely must, such will be the case.

On the other hand, there is no doubt of the great gain to be made by taking carp in the spring and early summer, when they come into the shallows and marshes in such great numbers, and holding them over to fall or winter, when the market price has sometimes multiplied fully tenfold. Let us take, for example, a suppositious case, based, however, on actual conditions. A moderate sized pond could readily accommodate, let us say, 50 tons of carp, and these could be obtained with comparative ease during the spring. At this season, when the fish are most plentiful, the price is often as low as 30 cents per hundred pounds, so that the market value of the whole 50 tons would be but \$300, even if they could be disposed of at all at that time; for it often happens that when the fish are so plentiful many more are brought in than can be used, and great numbers bring the fisherman almost nothing, being only sent to be made into fertilizer. Now let us suppose that instead of disposing of these fish at such an unsatisfactory figure the fisherman pens, or otherwise holds them over the summer. Under at all favorable circumstances the loss in that time surely ought not reasonably to be greater than 10 per cent of the total number of fish impounded, even allowing for the damage to fish by handling.

Indeed, in a properly conducted pond, there should be no loss in weight at all. The growth of the living carp, if properly fed and cared for, should adequately offset the loss of individuals. For the sake of fairness, however, we shall assume a loss amounting to 10 per cent of the weight, and that the total weight of fish recovered from the pond in the fall amounted to one-tenth less than that put in—in other words, to 45 tons. Now, in the late summer, fall, and winter months it is not at all unusual for the price of carp to go to 2, 2½, or

even 3 cents per pound, a price ten times as great as that of the spring. Many of the owners of carp in ponds and pens wait only for the market to reach 2 cents per pound, and then fish their ponds and sell the fish. If we market our 45 tons at this moderate price, they now bring us the sum of \$1,800, in comparison with which their original value was insignificant.

It is needless to say that not all who make this venture are so successful. From inexperience or ignorance of the conditions required some of the ponds are very unfit for carp, and the mortality is much greater than we have estimated above. Or in some cases, especially in the pens, the fish have no natural food, and they can be maintained in good condition only by feeding them artificially. The cost of this must, of course, be deducted from the profits, and may amount to a considerable item. Furthermore, the initial cost of constructing a pond may constitute a relatively large investment, and account must be made also of the necessary labor to maintain it and to care for the fish. All these items vary greatly with local conditions, for whereas a pond may be constructed and operated very economically in one locality, in another place it may prove very expensive. Certain it is, however, that small ponds are each year proving an acceptable source of subsidiary income to many farmers whose land is favorably located, while individual fishermen and fishing companies are yearly going into this business of holding over carp on a more and more extensive scale.

CONCLUSIONS.

As was stated in the introductory remarks at the beginning of this report, the main purpose of the investigation was to determine, if possible, whether the introduction of the carp into the United States had proved a benefit to the country or whether the fish had turned out to be so detrimental to the fisheries and other interests that it must be considered as a nuisance. In other words, have the twenty-five years or more that the carp has lived in our waters, and in which it has increased to such a surprising extent, justified the belief of those who were instrumental in its introduction that it would fill a place in the economics of our fisheries that could not be taken by any of our native fish; that it could, with little trouble and at small expense, be artificially raised in ponds and other small bodies of water unsuitable for the culture of any equally desirable native species, thus affording a cheap and ready supply of fresh fish to many who would otherwise be unable to have any fish at all; and finally that it would populate such of our lakes and streams as were unfavorable for inhabitation by finer species, and contained only buffalo, suckers, and the like?^a

^aThe good qualities claimed for the carp, which led to its introduction, will be found enumerated on page 544.

As regards the culture of the carp in this country, we find that, although there was for a few years an enormous demand for the young fish—hundreds of thousands of which were yearly distributed free by the United States Fish Commission and by many of the state commissions—their culture was soon abandoned in nearly all cases and the fish allowed to escape into the open waters of the vicinity. There are a number of reasons to account for this. People were expecting too much. They rushed into carp culture in entire ignorance of the conditions requisite for its successful operation, and, such being the case, it is no wonder that they were disappointed in the results and that their attempts were failures. In the second place, there was also a general disappointment in the qualities of the carp as a table fish. Undoubtedly, as in the case of its culture, too much had been expected, though perhaps not without some justification. Still, the bulletins that had been published and distributed made frequent mention of the muddy flavor of the carp when grown under unfavorable conditions, and emphasized the necessity of keeping such fish for a time in clear water before killing them. Then, too, the fish were often eaten at the wrong season, during the spring and summer months, when their flesh is admittedly poorer in quality than in the fall and winter. This is true of most fish that live in rather shallow and sluggish waters, and even black bass are seldom caught and eaten at these seasons. Perhaps even more important was the matter of cooking. As has been mentioned in the body of the report, it is generally conceded that carp should be cooked in special ways, and the Germans especially have many elaborate dishes which they prepare from its flesh. Most of those who tried the fish here cooked it as they were accustomed to cook our native fishes, and decided that it did not compare favorably with these, though, according to the statements published by Smiley (1886), many appeared to be very enthusiastic about it. Finally, another important factor which probably led to the abandonment of pond culture in many cases was the increasing abundance of carp in the rivers and other open waters. It was found that what fish were wanted could be obtained with less trouble from the open waters than they could be raised.

The whole question was admirably summed up in the Report of the Michigan Fish Commissioners for 1884–1886 (Michigan, 1887, pp. 41, 42). This report not only contained much cool-headed advice to those who were contemplating launching into carp culture, but was almost a prophecy of the outcome of the introduction of carp into the country. After insisting that the carp will not be a success unless properly cared for, the report continues:

From the fact that carp could be successfully grown in warm and muddy waters, it was inferred that they would be just the fish to plant in our comparatively shallow lakes throughout the State, and from the published accounts of their amazing fertil-

ity, and rapid growth, it was confidently expected that in a very short time a large food supply would be furnished.

While we believe that the carp will eventually prove a valuable addition to our food fishes, and especially fill a want amongst the rural population, still we would caution those desiring to engage in this industry to go slow, to test its value for food in comparison with our native varieties; to see whether they like carp to eat before they spend any considerable sums of money in the construction of ponds, etc.

Nothing so much^a injures any enterprise as overestimating its importance. Estimates are still wanting as to the cost per pound for raising carp, and the fact that they can be so readily procured must in a short time make them so plentiful in the markets as to bring the price below the cost of production, if one-half of those designing to engage in their culture should realize their expectations.

There can be no doubt that the carp is a nutritious and healthy food fish, but there is a doubt whether they will please the taste of the general public who have been accustomed to the taste of our native fish. In the trial made by the Commission and their friends, when direct comparison has been made with our native fish by cooking them in the same manner and at the same time, the decision was that they seemed inferior to the fish with which they were compared, namely, the black bass and the wall-eyed pike. But in the regions where fish, even poor ones, are a luxury they will provide a great boon. In a State so exceptionally well supplied, however, with the finest fresh-water fish in the world, as our State is, it is doubtful if the carp will become either a favorite food or a source of profit for many years to come.

Although the carp did not fulfill expectations in the matter of pond culture, it has more than done so in the way it has adapted itself to conditions found in this country and the rapidity with which it has multiplied in our waters; and we find now that, instead of being generally used throughout the country and especially in those sections where it was thought it would be most appreciated on account of the poverty of the streams or the poor quality of their inhabitants, it is being sold almost entirely to the poorer classes of people in our large cities. The Illinois River, together with the other rivers of the Mississippi drainage system, is one of those localities in which it was thought that carp would be a most valuable accession, and such has turned out to be the case, though not in the exact way originally expected. Although practically not used at all for home consumption, it has nevertheless added very appreciably to the resources of the region.

With our constant immigration of foreigners and the formation and growth in our large cities of great foreign settlements, the problem of supplying these multitudes with cheap yet wholesome food becomes very great, and anything which helps to meet this demand is of great value to the country. From this point of view there is no doubt of the value of the carp and the benefit to be derived from its introduction. To pervert a common saying, in those places to which it is best suited it has made two fish to grow where but one grew before.

But now come the sportsman and the commercial fisherman, who maintain that, while all that has been stated may be true, the presence of the carp is entirely supplanting the fish which was there before,

and that that one fish was of more value than the two carp which have taken its place. This is especially true of such waters as the Great Lakes, and others that were well supplied with good native fish. Furthermore, the sportsmen and others claim that in various ways the carp does more than enough damage to offset its value in other respects. By these persons it is made responsible especially for the great decrease of water-fowl in recent years. These and other charges have been considered in the body of the report, and need not be discussed in detail here. In most cases the reported damage has been either greatly exaggerated or is entirely unfounded. Thus it was found that carp probably have little or no share in causing the decrease of the native fishes commonly taken for sport or for food; and that in the case of the black bass, at least, there is evidence indicating just the opposite—that the bass have actually increased in numbers in some places from having the young carp to feed upon. In the matter of uprooting vegetation, making the water continually roily, and injuring—possibly even completely destroying in some cases—the regular feeding grounds of the migrating ducks—in these cases the evidence goes very largely against the carp, though its effects have undoubtedly, in many instances, been greatly exaggerated, and more has been charged against the fish than it rightfully deserves. In certain places, such as reservoirs and lakes supplying water to cities, etc., there is no doubt that the carp is an unmitigated nuisance, and that its presence is undesirable. Nor can it be considered suitable for the cold, clear lakes of the north, such as are found in northern Wisconsin and in Canada; and fortunately the conditions in these are so unfavorable that it will probably never become so abundant in them as to cause much damage by destroying vegetation and roiling the waters.

Against these charges as to its detrimental influence must be set the things in its favor. Chief among these is that already mentioned—the value of the carp as a source of revenue to the fishermen in the regions where it occurs, and as a cheap food for the poorer class of people who can not afford a better fish. It is impossible to express in dollars and cents the beneficial results and the damage done and thus to compare them directly. The value of the carp fisheries of Lake Erie and the Illinois River region for 1901 was estimated at \$342,000 (p. 619, footnote); but there were no data for the rest of the United States. And no monetary value at all can be fixed for the damage done. It seems quite safe to say, however, that if the question were to be considered in this manner the benefits would far surpass the damage. Two other claims in the carp's behalf, which may prove to be of considerable importance, ought also to be mentioned. These are its destruction of the fluke-worm (*Fusciola hepatica*), and of the larvæ of noxious insects, especially mosquitoes. It is possible also that in

rivers, below cities, it may do important service as a scavenger, destroying the germs of certain human diseases, as it does the larval and encysted stages of the liver fluke.

Even were it possible to estimate the money value of the damage done, such a basis would not be an entirely fair one for comparison. Should the carp help to hasten the extermination of any of our water-fowl, or if it destroys the beauty of lakes, as is claimed, this is a harm which can not be reckoned in dollar and cents. As has been pointed out elsewhere, however, there are other and more influential factors at work in the destruction of the water-fowl; and in the other case special measures of prevention and protection must be employed.

And when we have decided whether the carp does more harm than good, we still have the real question before us. The essential problem is this: The carp is here, and here to stay; what are we going to do with it? How can we make the most of its good qualities and prevent it from doing damage? Even were such a course desirable, the extermination of the carp in our waters is out of the question. Mr. Townsend, in some remarks before the American Fisheries Society (Transactions of Thirtieth Annual Meeting, 1901, p. 123) stated the case well when he said:

We hear a great deal from sportsmen's clubs and from other sources as to how the carp can be exterminated. It can not be exterminated. It is like the English sparrow, it is here to stay. At a meeting of the American Ornithologists' Union a while ago, one of our foremost ornithologists stated that the European sparrow could not be exterminated in this country. I think it is the same with the carp. It is here to stay and we can not exterminate it any more than we can exterminate the green grass of the fields. I do not wish to pose as an advocate of the carp—I prefer other fish for myself—but I maintain that the carp has a place in good and regular standing in our big eastern markets, and I do not think that our great republic with its rapidly increasing population, can afford to sneer at even so cheap a source of food.

In the course of my investigations and inquiries I met frequent propositions that the government, or the respective state governments, should offer a bounty on carp. Nothing could be more futile than this, as has been abundantly illustrated in the case of the English sparrow. The best bounty that can be offered is an increasing market—a growing demand that will make fishing for carp a profitable business. The case in Lake St. Clair is a good illustration. While there I heard the bounty proposition frequently advocated by sportsmen who came to the flats to fish and hunt. But a shrewd resident said, let the state amend the laws so as to allow the taking of carp in nets, and there will soon be enough people fishing for them to reduce their numbers. Since then the laws have been changed so as to allow seining in the lake, and if the removal of enormous quantities of the fish (see p. 614) will do anything toward permanently reducing their numbers, such certainly ought to be the result there now. The lines along which it

seems that the market for carp may in the future be further developed have been pointed out and discussed in the section dealing with its food value and uses.

In another place was mentioned the possible amusement and recreation to be had in taking carp with hook and line. I am aware that the American sportsman will scoff at the very idea, and would regard the pastime with disdain. I wish merely to quote in its defense a paragraph from Goode's *American Fishes* (Goode, 1888, p. 412), in which he treats of the strenuousness of the average American angler:

There is a kind of pleasure known to English anglers which is cultivated by but few of those who are called by the same name in America—the quiet, peaceful delight of brook-fishing in the midst of the restful scenery of the woods and the meadows. It is difficult to imagine a thorough disciple of Walton chumming for striped-bass in the surf at Newport or trolling for Muskellunge among the Thousand Islands, drailing for Blue-fish in the Vineyard Sound, or tugging at a tarpum-line in the Gulf of Mexico. The muscular exertion, the excitement, the flurry and noise, make such sports more akin to the fiercer pursuits of hunting than to the contemplative man's recreation. The wisest, best and gentlest of anglers, those who have made the literature of angling akin to poetry, have not, as a rule, preferred to make a violent exercise of their fishing.

Nothing has been said in the present report about protection for the carp in open waters, since, whatever may be the opinion as to the fish's desirability, protection for it does not seem to be needed. I am of the opinion, however, that the phenomenal increase of the carp in those waters where it has been longest will soon reach its maximum, if it has not already done so, and that as the various factors become adjusted a more stable balance will be reached. It is conceivable that then persistent fishing may greatly reduce its numbers.

And now, should I attempt to sum up the principal results of the investigation in a single paragraph, I should say that, whereas the carp undoubtedly does considerable damage, from the evidence at hand it seems reasonable to conclude that this is fully offset by its value as a food fish and in other ways; that it can not be exterminated, and that the problem is how to use it to the best advantage—suggestions for which have been offered. Efforts should be directed to encourage utilization of the fish in all ways possible, since it appears to be a resource as yet comparatively undeveloped.

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