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Roosevelt Wild Life Bulletin

Charles C. Adams

SUNY College of Environmental Science and Forestry

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Roosevelt Wild Life Bulletin

OF

The Roosevelt Wild Life Forest Experiment Station

OF

THE NEW YORK STATE COLLEGE OF FORESTRY

AT

SYRACUSE UNIVERSITY
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** Resigned as Station Ichthyologist October 1, 1921.

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THE RELATION OF FORESTS AND FORESTRY TO HUMAN WELFARE

"Forests are more than trees. They are rather land areas on which are associated various forms of plant and animal life. The forester must deal with all. Wild life is as essentially and legitimately a part of his care as are water, wood and forage. Forest administration should be planned with a view to realizing all possible benefits from the land areas handled. It should take account of their indirect value for recreation and health as well as their value for the production of salable material; and of their value for the production of meat, hides and furs of all kinds as well as for the production of wood and the protection of water supplies.

"Unquestionably the working out of a program of wild life protection which will give due weight to all the interests affected is a delicate task. It is impossible to harmonize the differences between the economic, the esthetic, the sporting and the commercial viewpoint. Nevertheless, the practical difficulties are not so great as they appear on the surface."

Henry S. Graves,
Former Chief Forester, U. S. Forest Service.
Recreation, Vol. 52, p. 236; 1915.

THE NECESSITY FOR FIELD INVESTIGATIONS OF FISH

"In considering the subject it is well again to call to mind that the first essential necessary to maintain even fair fishing is this: All the work which it is possible for the State and national hatcheries to do by way of planting the waters should be supplemented by all the fish which may come from natural reproduction, and it should be so provided by law that the fish have every opportunity to spawn unmolested."

"Experts have solved most of the problems connected with the business at the hatcheries; but the field of investigation to obtain the best results in planting game fish in wild waters appears to be still open, and theorists are constantly discussing this feature in publications devoted to the interests of sportsmen.

"Here, then, is where the chief problem now lies, and it should not be left to novices to decide. It is universally recognized as the one important difficulty to overcome, and yet, strange to say, a majority of our leading fish culturists seem to have given the matter little or no attention in the past. They have devoted their entire time to solving hatchery problems, and at last these have been reduced to such an exact science that the experienced culturist can now calculate in advance to a nicety his season's output and the total funds required for its development. In the past it has been the custom of culturists to assume that their full duty was done when they had raised a large, healthy stock of fish for planting. But when we look for permanent results and benefits from their work, it is certain that their task was only half finished. In the future they must abandon the hatcheries to their trained subordinates and seek the streams, ponds and lakes, and there apply their talents."

Henry Chase.
Game Propagation and Protection in America, pp. 187-189; 1913.
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THE STATUS OF FISH CULTURE IN OUR INLAND PUBLIC WATERS, AND THE ROLE OF INVESTIGATION IN THE MAINTENANCE OF FISH RESOURCES

By Dr. William Converse Kendall

Ichthyologist, Roosevelt Wild Life Forest Experiment Station, Syracuse, New York

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INTRODUCTION

The original fish resources of the inland waters of North America were among the richest in all the world. The trouts, salmons, whitefishes, basses, perch, pikeperch, pikes and catfishes, are among the best food and game fishes known to man. This was a wonderful natural resource, which comprised not only a great variety of species
but also vast numbers of individuals of the most desirable kinds of fish.

Our fishery resources have not been adequately appreciated by the public, even during the great wave of agitation for conservation led by Theodore Roosevelt, because through the lack of constructive leadership on the part of those most interested in fishery matters, the fish failed to receive their due share of attention.

The State of New York, bounded by the Atlantic Ocean, Lake Champlain, the St. Lawrence River, Lake Ontario and Lake Erie, contains in its inland waters about 125 native species of fish. It thus has one of the richest fish faunas possessed by any State in the Union, and yet this resource is slipping through our fingers, as it were, in the main because of indifference and ignorance of its value and of how to care for it intelligently.

The following resume of the history of its original wealth and gradual decline, together with an estimate of its present status and future possibilities, may assist in orienting this resource among conservation problems. The emphasis on surveys and intensive investigations, it is hoped, will serve to discourage the customary indiscriminate planting, and the managing of this crop by promiscuous methods rather than on a basis of exact data, thoroughly correlated. Whether our inland fisheries will be stabilized or suffer further decline depends largely on which of these policies is emphasized henceforth.

The present paper sketches the broad outlines of some of the major problems involved in the fish cultural management of public waters, as they appear after years of study of this general field. The present drift of events seems to point very clearly to the conclusion that the main stronghold for game and fish in the future is to be found in the forests and waters of the non-agricultural and public lands. We thus anticipate an increasingly close relation among the problems of wild life and other phases of forestry in its modern sense.

**ORIGINAL CONDITION OF THE INLAND FISHERIES**

**Former Abundance of Fish.** That there was a great abundance of fish of various kinds in this country in early times is almost proverbial. Salmon, shad, alewives, striped bass and other kinds are said to have "swarmed" in all New England coastal rivers, and the inland waters "teemed" with brook trout, lake trout, and other choice fish. Concerning salmon, Goode ('03, p. 443) wrote: "Wonderful things are said about their abundance in colonial days. Every one has heard of the epicurean apprentices of Connecticut who would eat salmon no oftener than twice in the week." And he quotes from Peters' History of Connecticut, 1783: "The shad, bass and salmon more than half support the province. From the number of seines employed to catch the fish passing up the locks, one might be led to suppose that the whole must be stopped, yet in six months' time they return to the sea with such multitudes of young ones as to fill
the Connecticut River for many days, and no finite being can number them.” Such accounts, of which there are many, pertain to the coastal streams accessible to the fish from the sea, but the impression prevails that inland waters were likewise replete with fish. There may be a question as to what extent such a belief is justified.

Authentic accounts of the fish life of inland waters are rare. Some fifty years ago, Watson (’76), writing of salmon in Lake Champlain, says: “When the writer first became a resident of the district in 1824, many of the original settlers of the country were yet living, who were men of respectability and position, and of undoubted veracity. Their tales of the abundance of the salmon which prevailed at that time for their acceptance exercised the strongest faith in the truthfulness of the narrators. Coming from the unimpeachable sources they did, and corroborated by uniform traditions, and the current of universal testimony, by actual observers or participants of the incidents, there was no hesitation in receiving the statements as authentic and true. I have heard accounts from several of these individuals that when they immigrated many streams were so thronged by the salmon that it was unsafe, at particular seasons, to ride a spirited horse into them for the reason that the fish were so abundant and bold that they would fearlessly approach the horse and strike him with great force by the powerful muscular action of their bodies. It was often represented that it was a common pastime, as well as a most desirable means of obtaining food at that time, to drive a team into some of the shallow tributaries of the river, and from the wagon spear the salmon with pitchforks, and thus obtain in a few minutes all the fish needed for consumption. Many of the salmon taken in this primitive method would reach twenty pounds in weight.”

The same author cites records of 1776 and 1777, which indicate that a pioneer in the Champlain basin had “complimented the American Army with 1,500 salmon in one year.” Another incident, related by “so intelligent and reliable authority” that it corroborated the “almost incredible traditions of the former copious prevalence of the salmon in these waters,” was to the effect that about the year 1800 or possibly a year or two earlier, as he was fording the Little Au Sable, a small shallow stream, near its mouth, the passage of his wagon was largely impeded by the throng of salmon which was in the stream, and he readily caught and threw upon the bank all he wished to take. Another account was that early in the past century five hundred salmon were taken in a single afternoon from the River Boquet, a tributary of the lake. Still another authentic account was that of 1,500 pounds of salmon having been taken by a single haul of the seine, near Port Kendall in the year 1823. These facts, the author thought to be “sufficient to sustain the proposition that the waters and the tributaries of Lake Champlain were teeming at a former epoch with salmon to an extraordinary, if not unexampled, extent.” It is further stated that in 1838 one man caught 50 or 60 salmon in the Ausable River, where no salmon had been seen for
15 years. This appears to indicate that the salmon had ceased to "abound" in Lake Champlain as early as 1823, although more or less sporadic occurrences were afterwards reported. In his History of Vermont, the Rev. Zadock Thompson (142), says of the salmon: "Only straggling individuals are now met with in Lake Champlain. I have heard of only one being taken here during the past summer, and that I did not see."

Salmon used to occur in Lake Ontario and frequented streams in New York and Ontario for spawning. In New York the most important stream appears to have been Salmon River, but they also ran up the Little Salmon and Oswego Rivers, and Little Sandy and Fish Creeks. With a view of the possible restoration of Salmon River as a spawning place for salmon, the United States Fish Commission instituted inquiries in that region in 1894. The oldest inhabitant interviewed was 90 years old. He stated that he moved to the locality in 1808 and remembered the rivers as far back as 1810. According to him salmon plentifully ascended the river to spawn, until the first dam was built in 1838. Another aged resident had speared and seined salmon for 70 years, and still another had fished there since 1835. Others had known the river and fished for salmon from 1850. Concerning the early abundance of salmon the following statements were elicited from those interviewed: Salmon were always plentiful until prevented from ascending the river by dams, or until about 1840. One man had known of 300 salmon being taken by a skiff in a single night. Another had seen 106 salmon taken in one haul of the seine. Notwithstanding the impeded ascent of the salmon, the river continued to be productive below the dam for a number of years. About 1850 it was said that an average night's catch was about 20 to 50 salmon to a boat, and that about 50 or 60 men were engaged in fishing for them.

In 1860, it was stated than 2 men in a skiff would get 30 salmon in a night and that 9 men, between Selkirk and Pulaski, made a partial living by salmon fishing. In 1868, a dozen salmon to a skiff in a night was considered a good catch, and in later years one persistent fisherman succeeded in catching 1 to 12 salmon in a season, although it appears that about 1880 from 60 to 100 salmon were taken in a day by gillnets, near the mouth of the river.

The foregoing indicated very little as concerns the actual abundance of salmon in the earlier days. That there was a decrease is manifest. The unknown factors are too many for definite computations. The duration of the fishing period may be approximately ascertained, but the number of days of actual fishing in that period is not known. The number of fishermen also would affect the computation. When the one man got 300 salmon in one night's fishing, how many other fishermen were there and how many fish did they get? By taking the stated average quantity of fish to a boat in a night, the stated number of fishermen at the same time, and assuming when the average was maintained, a result is obtainable which may or may not more or less definitely indicate how numerous the
fish may have been. For example, in 1850, an average night's catch to a skiff was, say, 20 salmon. It was stated that there were 50 or 60 fishermen on the river at that time. It is not known whether they were individual operators, not counting assistants, or whether they represent the total number of men concerned. Inasmuch as two men operated a skiff, let it be assumed that there were 25 boats fishing. This appears reasonable as one man said he had seen 20 boats operating at one time. Then assuming that the average was maintained for 10 nights only, the total catch would have been 5,000 fish.

Now it was stated that 10 years later (1860) 2 men in a skiff would get 30 salmon in a night; and that 9 men between Selkirk and Pulaski made a partial living by salmon fishing. It is possible that there were 9 independent operators, each representing a skiff, so their catch each night would amount to 270 fish, and in 10 nights to 2,700 fish. This is more than half the amount taken in the previous instance, which might be accounted for by the increased average per skiff due to the decrease in number of fishermen.

The foregoing figures prove nothing more than the fact that the quantity of fish caught was in proportion to the number of men fishing. The more fishermen there were, the fewer fish to a skiff were caught; and, therefore, the presumptive evidence that the number of salmon present in those respective seasons could not have greatly exceeded the number caught. In the first instance possibly, but not probably, the total quantity caught was double the quantity computed, so it might be said that possibly the season's run was somewhat more than 10,000 fish, inasmuch as some must have escaped capture and bred somewhere to provide the runs of subsequent seasons. It would hardly seem probable that 10,000 fish were caught in any one season, unless there was a waste of fish. There was evidently a comparatively rapid decline. The market was limited and that the quantity of fish was less than the demand is indicated by the price per pound received, which was 12.5 to 20 cents in 1855, and 15 to 20 cents in 1860. In this connection it is interesting to note that in the very early history of the locality, salmon were bartered in the neighborhood, one pound and sometimes two pounds of salmon being exchanged for one pound of pork. In 1812, it is said, salmon brought 2 cents a pound; in 1820 the price was from 4 to 6 cents; in 1840, from 5 to 6 cents; in 1855, from 12.5 to 20 cents; in 1860, in Syracuse and Utica, 15 to 25 cents per pound.

In this country the salmon was always a food fish and apparently seldom, if ever, caught by angling methods. But from very early days the brook trout was a game fish as well as a food fish, and was sought by anglers, both young and old.

The older of us can remember the stories told by our grandfathers concerning the abundance of trout in the streams and lakes, and how they used to make periodical trips each fall to certain waters to catch trout, which were salted for winter use, or how they caught them through the ice in winter. A single story will serve as an illustration. One man (Rich, '83), all his life familiar with the Rangeley
Lakes region in Maine and long before it became widely known to anglers, wrote in an article in a sportsman's journal as follows: "Every brook, every stream, and every pond and lake was literally full of them. Of course, there were proper times to fish at certain places; for instance, at places where ample quantities could be taken at one time, none could be had at another time. I have seen the Cambridge River at the foot of Umbagog so crowded with trout rushing up stream that you could almost walk across it on the backs of the fish (if this is a fish story, it is an actual fact). And again in the fall of the year great schools would rush into the mouths of rivers and coves near their spawning grounds, so as to fairly blacken the water, and they were hungry.

"At the first freezing over of the lakes and rivers, at the mouths of small brooks and around certain stony banks in the lakes, and near late spawning grounds, hundreds of pounds could be taken in a day, and the hunters were pretty sure to improve these opportunities."

In another place, the same writer graphically described the first run of trout in the Kennebago River in 1884, where, he said, from the last of September to the freezing of the river in November, the trout resorted to spawn. He wrote that on September 22, having been attracted by the splashing of the water, sounding "like a drove of moose wading in the river," he saw a large school of trout, many of which were of large size, jumping out of the water and going through various maneuvers as they made their way up the river. They continued to run in large schools until all the spawning beds above along the river were fully occupied. He says that the number of trout running up the river could not be estimated but that in the small space of about 5 rods the spawn takers secured 500 trout from October 1 to 12.

The Rev. Zadock Thompson, in his history of Vermont, previously referred to, gave a very interesting account of the brook trout in Vermont, from which the following is quoted: "The brook trout is more generally diffused over the State than any other species of fish, there being scarcely a brook or rill of clear water descending from our hills and mountains in which it is not found. When the country was new they also abounded in larger streams, where they often grew to the weight of 2 or 3 pounds. But they have been diminished by the causes already mentioned and have been sought after with such eagerness as the most delicious article of food of the fish kind that they are now seldom taken in our streams exceeding half a pound in weight, and much the greater number of them weigh less than a quarter of a pound. In many of the ponds they are still taken of a larger size, but their flavor is thought to be less delicious than those taken in running water, especially in ponds with muddy bottoms.

"The trout is usually taken with the hook, and the bait universally used is the red earthworm, everywhere known by the name angle worm. Fishing for trout is a favorite and common amusement, and parties frequently go 15 or 20 miles for the sake of indulging in it."
The foregoing are but few of many examples indicating conditions of the fisheries before and after interference by the white man, and show to some extent upon what sort of evidence the traditions concerning extraordinary abundance of the fish were based. That every body of water was originally replete, to its biological capacity, with fish for which the waters were suited and to which they had access is in accordance with biological laws. It is undoubtedly true that fish have been observed in great numbers in streams accessible from the sea, so numerous in fact that it would almost seem that one could walk across on their backs, but how many fish actually composed such an aggregate is another matter. And when limited inland waters are considered it is still another matter. When the fisherman got 1,500 pounds of salmon at one haul of the seine in Lake Champlain, at first thought it may seem to have been a remarkable catch. But if those fish had each weighed 15 pounds, which has been stated to be the average, only about 100 fish were caught. How many fish could have been taken in subsequent hauls throughout the season? The fact that it was recorded as remarkable indicates also that it was unusual even in those early days. It is not stated whether or not the 1,500 fish with which the American Army was "complimented" in one year in 1776 or 1777, were all that were caught. It would appear that probably there were not many, if any, more fishermen in the region at that time. If there were, the question arises as to their success in the salmon fishery.

After all, the point is that whatever the number of salmon in former years, there are no salmon in those places today.

Depletion of Fisheries. In the olden days, it has been said, the salmon was a food fish rather than a sportsman's fish. So, also, with many other fishes which are now scarce. It is that fact that has led to the scarcity of many species which are now esteemed alike for their food and game qualities.

According to traditions, inhabitants of the neighborhood of waters which "teemed" with fish, captured them by the wholesale. The fish were taken primarily for food, usually for home consumption, but sometimes for the market. But those which were not disposed of in those ways were frequently fed to hogs or used for fertilizer. Those inhabitants usually did their fishing at times when the fish could be most easily caught in the greatest numbers. Accordingly the principal fishing operations were at or near the spawning time, when the fish were often wastefully slaughtered. Excessive and untimely fishing were not the only factors concerned in the depletion of fish in lakes and streams. In the old days one of the most potent of other factors was the erection of dams in the streams with no provision for the ascent of fish. Fish which went down stream could not get back. Thus many species were shut out from their breeding places, and unless other suitable places were found, the fish died out. If suitable spawning places at first existed below sawmill dams, ere long the waters were choked with sawdust and other mill waste. The destruction of the forests and the drainage of the lakes, ponds and
swamps in many places, have all had a most unfavorable influence upon fish.

Concurrently with an increase of population the decrease in quantity of fish was hastened. At first, sportsman-anglers were few, and as a rule they sought only game fishes of highest repute, in which category only a comparatively few species were admitted. Most of these were members of the salmon family. Usually salmon fishing was restricted to Canada as, for the most part, New England streams had been depleted, not wholly on account of excessive fishing, however, but also owing to obstructions to the ascent of salmon.

Finally there came a time when the class of game fishes had to be enlarged by the admission of other species, and the old aristocrats of the class became less valuable as commercial food products and more valuable as objects of sport. Accordingly, when given any conservative attention at all, one after another the fish were removed from the commercial fish class, and were legislated for in behalf of the angler. So today there is scarcely a fish, that will take a baited hook, which is not somewhere, by some angler, regarded as a game fish. Furthermore, many of those species, formerly regarded as coarse fishes and neglected by the commercial or market fishermen, finally became of economic importance, and they, too, began to decline.

**Early Measures for Restoration.** In some localities declines became quite noticeable in the early history of the fisheries, and various measures for protection of the fish and restoration of the fisheries were enacted by state legislatures. At first, legislative acts concerned food fishes only with little or no consideration of the angler's interests; but after a while two interests had to be recognized, that of the commercial fisherman now being paramount and that of the angler secondary. The division of interests gave rise to problems of where to draw the line between the groups which should receive special legislation as commercial or food fishes and game fishes respectively. Certain fishes had to be admitted to both categories, although the interests of the commercial fishermen and the anglers sometimes conflicted. The locality finally often determined the class to which certain fishes should belong, giving rise to special legislation with its attendant advantages and disadvantages. So fishes which in one locality became classed as predominantly commercial fishes, in other places were classed as game fishes only, and their sale in the markets was restricted or absolutely forbidden.

As has been said, while at first protective and remedial legislative measures were directed toward the commercial fishes, later special game fish legislation was enacted and various fishes were given game fish legislative attention. These fish laws necessarily varied in different states and sections of the country, and almost everywhere appear to have failed of their purpose.

The unsatisfactory results of protective and restorative fish and fishery legislation were so marked that the introduction of fish cul-
ture or "artificial propagation" was hailed with unbounded enthusiasm. To those persons most concerned—the State Commissioners, fishermen and anglers—artificial propagation was the "Sesame" which was to open the gates through which the sea, rivers, lakes and streams were to be rehabilitated. In 1872, one enthusiast said: "Every stream on the Atlantic seaboard can be so filled with shad that they will sell at all the fisheries at one cent a pound within the next ten years." Another predicted that "the time is not distant, if we may be allowed to forecast the future, when every available river or stream of the continent will be as carefully cultivated as ever our soil was, for the augmentation of this great source of food."

Dr. Theodatus Garlick of Cleveland, Ohio, is generally credited with the first successful attempt at artificial propagation in the United States. In 1857 he published "A Treatise on the Artificial Propagation of Certain Kinds of Fish, with Descriptions and Habits of Such Kinds as are the Most Suitable for Pisciculture." While in his preface Dr. Garlick states that he would "endeavor to present the reader with not only a complete description of such American fishes as are best suited by their qualities and habits for artificial propagation and culture, but also the best methods of propagating and rearing them; together with the most appropriate kinds of waters for each kind described," his most signal success was with the "brook trout."

Concerning this first attempt Dr. Garlick wrote that early in the spring of 1853, Prof. H. A. Ackley and he decided to make brook trout the subject of their first experiment in artificial breeding. During the following years others went into trout breeding as private ventures. Some of the most noted of these fish cultural pioneers were Thaddeus Norris, Seth Green and Livingston Stone. In the early sixties Maine, New Hampshire and Massachusetts established State Fish and Game Commissions, which gave the marine anadromous fishes, such as salmon and shad, the first propagative and legislative attention, but incidentally extended their stocking activities to inland waters and to other fishes. Other states soon followed the example set by these New England States. Private enterprises, however, continued to exist in some of the eastern states. These latter were particularly interested in the propagation and sale of brook trout. There were numerous trout farms in New York, New Jersey and the New England States, which found a lucrative business in the sale of trout eggs, young fish for the purpose of supplying other ponds, and in furnishing hotels with full grown trout, which were sold for a comparatively high price.

The combined interests of private concerns and state commissions led to the formation of the American Fish Cultural Society, now known as the American Fisheries Society. This Society is credited with being one of the agencies instrumental in bringing about the establishment of the Federal Commission of Fish and Fisheries, now the Bureau of Fisheries, U. S. Department of Commerce.

The decline of the sea and river fisheries was the first object of
inquiry by the United States Commission. Subsequently propagation of game fish for inland waters constituted a considerable part of the function of the Commission, and still forms an important division of the Bureau. Federal fish hatcheries and fish cultural stations of one kind or another have been established in almost every state of the Union, and the states have their own hatcheries, sometimes as many as a dozen or more in one state. Millions upon millions of fish eggs have been hatched and the young distributed far and wide in waters of this country and foreign lands. Fish of various kinds have been imported from Europe and planted in the waters of this country, and thousands upon thousands of dollars have been expended in these operations. The results attained are indicated by the present conditions. (For a general account of the history and policies of the U. S. Bureau of Fisheries reference should be made to H. M. Smith, '10.)

PRESENT CONDITION OF THE INLAND FISHERIES

To the fisherman and angler there appears to be something radically wrong as concerns the food and game fishes of the inland waters. Notwithstanding the many years of extensive and intensive effort and great outlay of money, the expected results have not been attained. Shad have not been "reduced to one cent a pound." Atlantic salmon are extinct in nearly all the rivers of New England, and it is only in the remote and silent places that the brook trout can be found, naturally, in their former abundance. Even the extensive importations of extra-limital fishes have failed to supply the deficiencies except in scattered localities; only a few, if any, rivers, streams, lakes or ponds have been permanently restored or stocked to a self-maintaining point. A single example will serve to illustrate the present situation, as similar conditions obtain with other species.

Let us take the case of the "rainbow trout" which has been propagated and distributed for more than 40 years in the eastern states. There are but few localities where the successful results appear to be anywhere nearly commensurate with the expenditure of money and effort. In fact in the eastern states there are but few localities where the reports indicate that attempts to acclimate the fish have been at all successful. In the 40 years from 1880 to 1919, inclusive, the United States Fish Commission or Bureau of Fisheries has delivered to state fish commissions over 6,000,000 eggs and distributed more than 21,000,000 young "rainbow trout" in the states east of the Mississippi River. But the old problem still exists. What is the answer? To this question the law of cause and effect applies, as in all problems of like nature.

Causes of Deterioration. Inland fish culture developed, through the need of restoring depleted river fisheries, into restocking inland lakes and streams. In a commendable effort to improve the angling, in many cases, zeal and enthusiasm seem to have outweighed judgment and forethought, resulting in the idea that the assembling in
large quantities of every kind of available game fish in a body of water was a most desirable consummation. So, while most estimable species native to the waters were neglected (figure 20), exotic species (figure 21) were brought from other states, and even from foreign countries. It was a long standing practice, which to some extent still prevails, to exchange fish locally plentiful in one state for fish from other states and foreign regions.

These efforts to meet the rising demand were made without knowledge or consideration of the existing conditions of the waters or the possible effects of the introduction upon either the native or introduced fishes. In this respect early fish cultural distribution was of the nature of a venture rather than a rational procedure or experiment. But it was a natural and unavoidable concomitant of the distribution of non-indigenous forms, the nature and requirements of which the fish culturist of those days was necessarily ignorant. The trouble lay in not realizing that new factors were likely to disturb normal conditions, and that the way to regulate conditions already disturbed was to restore as nearly as possible original or normal conditions.

Indiscriminate planting of fish in the past and even today is the cause of much of the present unsatisfactory situation. Instead of trying to maintain a supply of fish in those waters to which the fish were known to be adapted and in which they formerly thrived, the fish have been scattered broadcast into large lakes and little ponds, near and remote, without regard to the habits or physiological requirements of the fish, and often to the detriment of the fish native to the waters into which the transfers were made.

As an example, the landlocked salmon of Maine, naturally occurring in only this one state, may be mentioned. It was one of the earliest fish to be propagated and distributed. In that State, too, the brook trout existed in untold numbers, and in some waters attained a very large size,—trout of 10 and 12 pounds being recorded. For years a chain of lakes in the northwestern part of the State was famous for its huge trout and renowned for its fishing.

The State Commission proceeded, as they thought, to add to the piscatorial attraction of the lakes in question. The first act was to plant sea salmon and later to transfer landlocked salmon from their native waters to those lakes. Not only were the salmon planted in the large lakes, but also in almost every little pond in the vicinity. This also holds true of most of the other principal lakes of the State. Even though it was regarded as possible and desirable to plant salmon in the larger lakes, it is hard to conceive of reasons why it seemed necessary to introduce them into every small accessible lake and pond already supplied with brook trout.

In the larger lakes of the particular chain mentioned the salmon has thrived, but at the expense of the original inhabitants. In the smaller ponds the only results obtained have been the decrease of trout and the capture of a few salmon now and then, which had grown up from the original plant. They did not thrive and reproduce because the conditions made it impossible.
A good example of the disastrous effects of indiscriminate fish cultural operations is that of a small pond in Maine, which was originally inhabited by a species of trout found in but two or three lakes elsewhere and in no other place in the State. As soon as it was discovered, it received fish cultural attention. Every season these fish were seined, stripped of eggs, hatched and distributed in other waters, until the trout became so scarce in the pond that it was fish-culturally unprofitable to operate any longer. Of all the young of this fish planted in other waters not one has survived, for the reason that no one of the lakes in which it was planted was suited to the physiological requirements of the species. Instead of endeavoring to increase and maintain this rare species in its one known favorable habitat in the State, landlocked salmon, steelhead trout, Scotch sea trout, and various other species were planted in the little lake,—which seems strange in view of the fact that not far distant was a comparatively large lake which was one of the four localities in the State where landlocked salmon naturally occurred. Of all the species planted in that little pond, not one now remains.

Another extreme example of this kind may be cited. Sunapee Lake, in New Hampshire, formerly was noted for its numerous and large trout. This fact led the Commissioners to try to make it still more attractive. Prior to fish cultural introductions, which began with landlocked salmon in 1867, so far as records show, the list of native fishes of the lake comprised an even dozen species. There were hornpout, common sucker, four species of minnows and chubs, two species of chars or so-called trout, eel, pickerel, sunfish and perch. From 1867 to 1900, fourteen other species had been introduced; namely, landlocked salmon, blackbass, smelt, whitefish, blueback trout, round whitefish, Loch Leven trout, brown trout, rainbow trout, chinook salmon, grayling, silver salmon, pike, perch and lake trout. although the last named was probably by accident. Of these the whitefish, pike, perch, blueback trout, Loch Leven trout, rainbow trout, silver salmon and grayling have never been reported, and only one or two brown trout have been observed. Of the introduced species only the blackbass, smelt, landlocked salmon, and chinook salmon ever manifested themselves in sufficient numbers to produce any appreciable effect on the conditions of the lake. The pickerel decreased in numbers, the perch became almost or practically extinct. cyprinoids were far scarcer than in former years, and the landlocked salmon had greatly decreased in number, when the chinook was introduced. The second species of char or "trout" was not discovered until 1885 or about that year. It had not been known anywhere prior to that time, but had evidently always existed in the lake, although unrecognized as different from the brook trout. It was subsequently described as a new species and at once became famous. It was then given the usual attention by the fish culturists and distributed far and wide in other waters with no positive results.

Here was a lake, which, according to tradition, at one time abounded in trout, the only known or recognized salmonids of those
waters. In early times the trout were killed in their spawning beds, caught through the ice, and netted in the lake. Necessarily such intensive procedure resulted in depletion. The very first step to repopulate the lake was not by propagation and planting of trout, but by the introduction of landlocked salmon. One year later smallmouth blackbass were introduced. Two years after the first plant of the latter fish smelt were planted. So far as the salmon were concerned this was a wise provision. In the State Fish Commissioner's reports no reference is made to planting of trout in this lake until twelve years after the planting of the first landlocked salmon, but up to that time over 16,000 salmon had been planted. But in the subsequent 30 years, over 1,000,000 young trout, and over 700,000 landlocked salmon were planted.

Up to about 1895 salmon were reported to be abundant and large, but in the following ten years they greatly declined in number and fell off somewhat in average size. In 1904 the chinook or king salmon of Columbia River was introduced and some were planted nearly every subsequent year. The first catch of this species was made two years later. They were caught each year subsequently in increasing numbers, and it was estimated that in 1910 from 400 to 500 were caught—ranging from a little over 2 to nearly 17 pounds. Large catches were reported in 1912 and 1913, but later they began to fall off in the number of fish taken, so that in 1917 the situation was as follows,—to quote the former State Fish Culturist of New York, who said a former New Hampshire Commissioner thus wrote him: "Fishing all gone to hell, not a salmon this spring; the chinooks were good for a time, but do not reproduce and have all been caught out. They have dumped lots of fish in the lake, but they seem to do us no good."

In this lake the decline of landlocked salmon was attributable to lack of suitable spawning places, and failure to plant more fish for a number of years.

Concerning the chinook salmon in Sunapee Lake, the present writer once had occasion to state that to his mind at least, a permanent self-sustaining stock of chinook salmon in that lake was unattainable, and, unless the existing stock was self-sustaining, it was a waste of time, money and fish to continue planting it, for the day would surely come when the supply of eggs from the west must fail; that if this fish has been maintained in the lake in the number then present, the disappearance of the fishes upon which it feeds must be hastened, and when the chinook stock also was gone, the lake would be worse off than ever before, and there would be some who would call for recommendations as to how to improve the fishing (Kendall, '13).

A letter recently received (July, 1922) from the Commissioner of New Hampshire says: "Chinook salmon have had their ups and downs in Sunapee, as in most lakes in the East. We have had several seasons at different times when the fishing was excellent and great numbers were taken. It was possible to estimate their age with considerable accuracy as in the different years the catches were practi-
cally about the same age, and it is pretty clear that none of them last over five years.”

The experience with the chinook salmon in Massachusetts has been similar to that of Sunapee Lake, and substantiates the foregoing prediction by the present writer. From 1913 to 1920 inclusive, 420,215 young chinook salmon had been planted in fifteen ponds and lakes in the State. The report of the director of the Division of Fisheries and Game of that State for 1920 (W. C. Adams, ’20), says: “The attempt to establish the Pacific salmon in Massachusetts waters was, at the best, an experiment, and, while in the matter of growth some of the fish planted in Long Pond, Plymouth, exceeded expectations, there was insufficient evidence that they reproduced. Indeed, the probability that they would fail to do so was always recognized, and that constant stocking would be the price of whatever salmon fishing our waters might afford. Thus as each fishing season came around the results were watched with the keenest interest, and more so than ever in 1920, because the catch of 1919 had fallen off materially from that of the previous year. The salmon fishing in Long Pond failed utterly in 1920.”

Long Pond had been stocked with 24,000 young salmon in the years 1914 to 1917 inclusive, and the following catches were subsequently made: In 1917, about 100 salmon, the largest weighing 7 pounds; in 1918, probably 350, running from 2 to 9 pounds, with 2 or 3 at 12 pounds; in 1919, about 800, but small sized, from 2 to 4 pounds; and in 1920, very few, the largest 4 pounds. However, the report for 1921 states that in several ponds an occasional specimen was taken, and in Long Pond upwards of 500 fish were caught during the entire open season.

It appears that in most of the ponds that had been stocked no salmon at all had ever been taken. In three of the ponds a very few specimens had been caught. Lake Quinsigamond, which was the first Massachusetts lake to be stocked and which had received 89,250 young fish during the years 1913 to 1917 inclusive, is said to have yielded possibly 70 fish in the third season, after which they disappeared.

In 1919 the planting of chinook salmon was abandoned by the Massachusetts Commission, as it was not possible to obtain a satisfactory supply of salmon eggs for the hatching work of 1920. Oregon advised that no eggs could be expected; in California egg-taking was the smallest on record; Washington could promise only 200,000 as against 600,000 and upwards in other years.

So it appears that the chinook salmon expectations in the eastern inland waters have failed, as most such random “experiments” have failed and always will fail; but the tendency to indulge in them still continues.

In the summer of 1921 a notice appeared in a Portland, Maine, paper to the effect that the Governor was arranging to have Sebago Lake stocked with Canadian sea salmon, “in order that there always may be good fishing in Sebago Lake.” The notice stated that if the
"experiment" was successful Canadian salmon would be placed in other lakes in Maine.

Sebago Lake is one of the four original landlocked salmon lakes, in which formerly the fish attained the largest size of any waters. The State maintains a hatchery on one of the affluents of the lake, and collects the landlocked salmon eggs from fish taken in that stream. Why, then, was it deemed necessary to resort to Canadian sea salmon in order to maintain good fishing in the lake? One of the reasons is that the Sebago salmon have for years been a source of supply for eggs with which to stock other waters, even small ponds in various parts of the State. If even the fish planted in small ponds had been restored to Sebago Lake, the effect upon the stock would have been appreciable. There is scarcely a lake or pond in Maine into which landlocked salmon have not been introduced. Landlocked salmon have been shipped promiscuously over the country, to the Pacific Coast, Europe and the South Pacific, and the "experiments" have so reduced the stock at Grand Lake Stream and Green Lake (both original salmon lakes) that now not enough eggs can be obtained there to maintain a stock and meet the demands for distribution. For additional eggs it has been necessary to draw upon the fish of artificially stocked lakes, and they are becoming reduced, if reports are true.

Titcomb remarks that in Lake George, New York (Titcomb, '22, p. 77), the experience with landlocked salmon is as follows: "In response to a public demand, landlocked salmon have been planted annually in the lake; 15,000 or 20,000 and sometimes more have been put in the lake or in the tributary streams for a long period of years. Reports indicate that the results have been unsatisfactory, an average of about ten mature salmon being caught from the lake each year."

It would appear that here is an example of long continued "experiment" with the usual results. Apparently no effort has been made to ascertain if Lake George is suited in every way to the salmon; whether there are suitable spawning beds and plenty of suitable food for all ages of fish from the time they are planted until they attain maturity. These are some of the conditions that should be first ascertained before further attempts to stock the lake with salmon are made, whether the salmon to be planted are fry, yearlings or older. The conditions to which reference has been made are not restricted to any one state. They are nationwide, and it may be added worldwide in some respects. To a great extent all are in the old groove of error. The wonder is that only a few of the more intelligent have recognized the error and have made any effort to profit by past mistakes, and that the majority are ever ready and willing to subordinate reason to personal expediency or selfish ends. Man has ever been an insensate, irrational, time-serving destroyer. Many of our fish and game and conservation officials have had the public interest at heart, but have been handicapped by the political factor, which, controlled by more or less powerful individual and organized interests, was, and still is, a factor tending to instability.
The results of such conditions are manifested in some of the present problems of conservation, and the author is here constrained to express his firm conviction that these problems will not be solved or conditions greatly improved until a way is found to harmonize the individual and organized interests with the public interests, as they pertain to fish and game. And, furthermore, unless harmony is attained it will not be many years before there will be no fish and game interests to harmonize or fish and game to conserve. And, again, if he may be pardoned for referring derogatively to the sacred institution of political favor, the author is compelled to say that no harmony can be attained, no conservation consummated, until that factor is eliminated.

Remedies for Present Conditions: Investigations. In his annual report for 1921, W. C. Adams, of the Massachusetts Conservation Commission, referring to the early depletion of fish and game, says: "It is useless to inveigh against the profligacy with which this great wealth has been squandered in the past, save for the lessons that may be drawn for present and future guidance. While we take pride in contemplating the amount of wild life still remaining in our comparatively small State, such pride must be fully tempered by the realization that even we, who have had and still possess one of the most enlightened public opinions on this continent, have wasted our substance in riotous living."

This great wealth which has been "wasted in riotous living" can never be restored, but what there is left can be so invested and controlled that it will not grow less, and even perhaps increase, providing we learn our lesson, not only from the "profligacy" of our pioneer ancestors, but from the results of defective fish cultural policies and practices of the last half century, which to no small extent continue to this day.

W. C. Adams previously wrote ('20) that the greatest concern of those who are studying the relation between the wild life of any given state and the increasing drains on it, through the taking in each year, is the fact that there is probably no species of game bird or fish which is more than holding its own. The annual production of the bird farms and fish hatcheries is not in proportion to the increasing sportsmen and fishermen who take to the fields, and very little or no margin is left for the inroads on the stock due to unfavorable breeding seasons, forest fires, cutting of the covers, severe winters, and ravages of vermin. While Adams referred particularly to game birds, the principle is applicable to the game fish situation, even to include unfavorable breeding seasons, forest fires and cutting of the covers.

The previously discussed perpetuation of erroneous practices and mistaken policies of the past, must be recognized and modified. The remedial policies of the past may be likened to the administration of a narcotic drug to alleviate pain, the cause of which was unknown. It developed into a habit which is now difficult to break. In many instances its continuance or cessation signifies the same
thing—the death of the victim. The only hope offered is in an effort directed toward the elimination of the drug from the system and the restoration of its normal functions, so far as normal conditions can be restored.

The problem is how to eliminate the drug from the system and how to restore normal conditions. A former Federal Commissioner of Fish and Fisheries said: "The fishery problems of fresh water are undoubtedly simpler than those of the seas, but they are certainly less directly approachable than the problems of agriculture which have met their solutions. It is not surprising therefore, that throughout the country in matters of fish culture, there is yet too little endeavor to find real causes or to apply appropriate remedies."

To continue the medical figure of speech, as previously suggested, the early and to some extent late administration of remedies were in the form of "shot-gun prescriptions," without knowledge of the anatomy and physiological processes of the patient,—or even the cause of the affection or the therapeutic properties of the remedies employed.

In other words, in the past, millions upon millions of fish have been planted in lakes and streams of the United States without any scientific investigation whatever for the purpose of determining whether the waters were suitable for the fish which were proposed to be planted in them, or whether the fish were desirable for those waters. The situation is that hundreds of thousands of dollars have been spent and millions of fish have been wasted without results of practical value having been obtained.

To quote again from W. C. Adams of Massachusetts: "It is elementary that the largest amount of wild life will be found in the area (whether land or water) that is most adapted to it, and where food and protection (in its fullest sense) are present to the economic maximum. It is a fair assertion that there is no area of land or body of water in this Commonwealth today on which primeval conditions have been maintained or artificial conditions developed to the point where it can be said that that area is in such physical condition that it will maintain indefinitely its full quota of wild life. If this is true of certain areas which have had special attention, then we are in a position to visualize what is the actual condition throughout the entire State, and how hopeless it is to expect great increase in the stock of wild life until conditions approximating the economic maximum can be created."

This situation is not peculiar to the Commonwealth of Massachusetts. It is the prevailing problem almost everywhere, and the question appears to be how to establish a balance between game fishes and their food supply and maintain it with satisfactory fishing.

About thirty years ago, concerning the stocking of streams, Dr. Barton W. Evermann (64) indicated that "to do this work intelligently it must be based upon a knowledge of the natural conditions under which each species thrives, which of the factors in its environ-
ment are essential, which only desirable, which negative, and which detrimental to the best life and growth of the fish. . . . This of course means careful observation and study of all the physical, chemical and biological features of each stream, for these are the conditions, forces or elements which together constitute the fish environment, and which determine the presence, abundance, distribution, and condition of the various kinds of fishes found in each particular stream or lake.”

Dr. Evermann further pointed out that the temperature and chemical character of the water, the volume or size of the stream or lake, the character of the shores and bottom, and the surrounding country, all must be ascertained. Not only these facts, but also the life histories of the fishes themselves, what other species of fish and what other animals and plants are found with them, and their abundance and habits, should be learned. Then after the determination of these facts of the fishes’ environment, a second and vastly more difficult series of investigation must be taken up, namely the bearing of these facts upon the life of the fish. “The whole subject of the relation of the various animal and plant forms found in our waters, their action and reaction upon each other, and their relation to the physical as distinguished from their biological environment is the subject which is demanding investigation and upon which investigation must depend all important advances in fish culture and fishery legislation.”

All this means that in undisturbed nature, there is an approximate balance or counterpoise of interrelations of the organisms composing the animal and plant life of every body of water, subject to automatic regulations. Where there is an interference, the balance is tilted one way or the other in direct proportion to the amount of interference. Every body of water, large or small, has a limit to the amount of life it can support, and any interference that produces an excess of that amount, or any part of it, proportionately deranges the balance. An undue reduction of any part of that life may result in an over-increase of some other parts, with a final result that these, or still other parts may be reduced. In other words, the organisms are not only interrelated but are more or less interdependent, and it cannot be foretold how far-reaching and disastrous the effects of the destruction of any one of them might be.

While natural phenomena may affect the balance, the principal factor of interference is man. Apparently nature did not take man into consideration when she adjusted the balance, and for the reason that his influence has been mainly destructive, in many instances the conditions have been so upset that he has felt called upon to effect a readjustment, which he has endeavored to accomplish by means of fish culture. In his efforts in this direction he has not always been guided by sound judgment, as has been shown, and too often the consequences have been that sooner or later the conditions have become worse than they were before.

For example, there have been waters in which pike and other fishes have lived in reciprocal counterpoise from time immemorial,
notwithstanding the condemned "characteristic voracity of the pike." Supposing that at some particular time the pike had been rendered less voracious, the tendency then would have been toward an undue increase of the natural objects of that voracity, which had probably been relatively as voracious on their own part in devouring the eggs and young of the pike. The increase of these forms might have resulted in the extermination of the pike, which would naturally have been reflected upon the other forms by depriving them of a part of their customary and requisite food supply, consisting of the eggs and young of the pike, and so have resulted in the decrease, deterioration, or extinction of these forms upon which the pike had exercised that quality, which has been generally regarded as superlatively bad.

This is a phenomenon that is usually manifested as a result of over-fishing, which amounts to the same thing as depriving the pike of its voracity, and similar to what happens when blackbass are introduced into pickerel ponds — of which there are many instances, but the cause of which has not been fully recognized. For instance, it has been recognized that blackbass have practically exterminated pickerel in certain waters, but why the blackbass afterward deteriorated in size and number did not seem explainable. These facts may be equally applied to other fields and fishes, as respects their artificial distribution, and particularly to the members of the pike family itself, for it should be borne in mind that the reverse process of the foregoing is just as effective. If the pike should be rendered more voracious, or, what amounts to the same thing, unduly increased in number, it would signify that sooner or later the food supply would be depleted, with the result that the pike would be forced to depend more and more upon its own young and would finally figuratively swallow itself (Kendall, '17).

Let us consider a more specific but still somewhat hypothetical example. It is stated that the main dependence of lake trout in Lake George is the whitefish. Both fish are indigenous to the lake. They were both factors in the original balance to which reference was previously made. The original food supply of the original trout was therefore in equipoise with the trout. Apparently something has happened to upset that equipoise which is manifested in a decrease of size and number of lake trout. This should result in an increase in number of whitefish, if there were no other whitefish eaters in the lake. If this has happened the lake trout stocking limit depends upon the present amount of whitefish as food, other things being equal. The lake trout is said to have no competition for that food. The main subsistence of the whitefish is Entomos-traca, for which there are several kinds of competitors, such as minnows and the young of other species of fish. An over-increase of competitors would decrease the food of the whitefish. A decrease of the whitefish food would be at the expense of the whitefish. An over-increase of competitors for the whitefish food would result from a decrease of those forms which maintained the balance
by subsisting upon those competitors. "Pickerel" subsist largely upon minnows and to some extent upon the young of other fishes. Pickerel have become scarce in Lake George. Minnows should have increased in proportion. The minnows eating whitefish food deprive the whitefish in proportion to the increased amount eaten by minnows; the resulting decrease in the number of whitefish deprives the lake trout of food; and the lake trout deteriorate and become less numerous.

Whether probable or not, it is possible that the growing scarcity of pickerel in Lake George has been an additional factor to that of man in reducing and maintaining the reduction of the lake trout stock. An increase of other fishes, particularly those which subsist to any extent upon Entomostraca would have the same effect. Hence before recommending certain measures for the reduction of pickerel and rockbass, it would be well to first make sure of our grounds for such recommendations.

Dr. G. Brown Goode once said ('94): "Scientific research involves four processes: (1) observation; (2) the record of the results of observation; (3) the classification and assimilation of these results; (4) their interpretation, both for immediate use and as a guide for subsequent inquiry."

There have been many investigations of inland waters when observations were made and the results recorded; some in which the results have been classified and perhaps assimilated; but there have been but few, the results of which have been interpreted for immediate use or subsequent guidance.

In his recommendations concerning measures to improve the fishing in Lake George, Dr. J. G. Needham ('22) makes two major divisions: I. Measures immediately applicable, and II. Measures looking toward the future. Under the latter division he says: "Go out after more knowledge. Nothing else will serve as a basis of rational procedure. In all doubtful and difficult fish cultural practices substitute carefully planned studies for random observations and exact knowledge for hearsay. On every hand are problems of fish production with the limiting factors unknown. The cure for this condition is research."

In conclusion concerning certain suggestions, Dr. Needham said that he made them because it was perfectly clear to him that all success in husbandry is based on intimate knowledge of the natural history of plants and animals and of their relations to each other. "This knowledge," he said, "we must have for fishes before we can have completely successful fish culture."

Consult the dictionary of a few years ago and you will not find the word "ecology," but modern dictionaries define it somewhat as follows: "The branch of biology which deals with the mutual relations between organisms and their complete environment." The foregoing statements concerning the necessity for biological and physical investigations of waters simply signify ecological study. In recent years ecological studies have become quite the
Fish Culture in Inland Waters

fashion with certain biologists and to some extent fishes have received such attention. But until recently such study has had little or no place in fish culture, although a few scientists and fish culturalists have recognized its importance in that direction. Neither the United States nor any individual state has ever made a complete survey of any lake or stream. There have been a few surveys that have been carried on for a number of years and a very few comprehensive studies of lakes, but never one that could be said to be thorough.

As long ago as 1886, Dr. R. E. C. Stearns wrote that a knowledge of the character or peculiarities of the environment or native haunts of the species selected for transplanting has to be obtained, and preceding the distribution and planting of the young fish an inquiry and consideration of the factors or physical character of the region in which it is proposed to make the plant of fish should be made.

These investigations having been made, a comparison of the conditions of the original and proposed new environment is the key to intelligent fish cultural distribution. But such procedure has never been the practice except in a very general inadequate way. To quote again from Evermann ('94): "Most of the work which has been done so far [in lake and stream study] has been in the line of determining factors in each environment, rather than guessing at what the factors mean. Heretofore great harm has been done by guessing at the facts and also guessing at their meaning. We believe it much better to be content for the present with the observation and recording of the facts, and wait until more facts are in before interpreting their meaning."

Within certain limits this is sound reasoning. But in all the years since those words were uttered the principal effort has been directed toward the accumulation of facts. Numerous investigations have been made and an almost unwieldy accumulation of facts has been acquired, and until more recent years there has been scarcely any attempt to analyze facts and apply them in practice. The result has been that early ascertained facts have been consigned to garret files, if not destroyed, or those which have been published have been buried in reports which are not generally available and therefore are virtually lost. When, finally, there has been an awakening to the absolute necessity for solving certain problems, the facts have to be sought anew.

A few states have made a beginning along some such lines as the foregoing pages suggest. For a number of years the Massachusetts Commission has had a biologist on its staff, but his duties comprised all biological subjects on problems pertaining to the fisheries of both inland waters and the sea. With his report for the years 1912, 1913 and 1914, he submitted a special report upon preliminary investigations for the systematic stocking of inland waters, in which he said: "Unless a State Fish Commission has a definite working knowledge of the inland waters, as a basis for methods of distribu-
tion, indiscriminate stocking will eventually lead to considerable loss. Extensive hatchery production increases rather than decreases this error, which can be remedied only by a systematic method of stock-
ing based on an accurate knowledge of the waters to be stocked.”

Referring to preliminary surveys begun three years before, the report says: “This preliminary study by no means completes the problem. Succeeding it should come more careful and detailed work, designed to increase ultimately the supply of food and game fish by (1) a study of the food, growth, spawning and habits of the different species of fish inhabiting various waters; (2) the determina-
tion of the species best adapted to certain classes of waters by an experimental study of type waters. There are, therefore, two parts; first, the preliminary general work, consisting of an extensive biological survey of the waters in regard to their general conditions to form a guide for future stockings, and a classification of these streams and ponds into certain groups, according to the similarity of the natural environment; second, an intensive study of various type waters, representing the groups above mentioned, as regards the effects of the natural conditions upon fish life. In such bodies of water records of temperatures, amount of food (plankton) and general changes which concern the problem of fish life should be followed for a number of years. The work of these type waters should serve as a basis for interpreting the conditions in other waters of similar nature.” (Public Doc. No. 25, 1916, p. 86.)

For a good many years physiographical and biological surveys of inland or fresh waters of various parts of the country have been made for one purpose or another by the United States Fish Com-
mission, now the Bureau of Fisheries. With the establishment of the Fairport Biological Station in 1908 on the Mississippi River, the Bureau began a definite program of investigation of these inland waters (Coker, ‘16).

Also, from time to time, the zoological departments of some of the state universities and colleges, have cooperated with various state departments, or even individual professors have independently undertaken such work, and the results of their studies have been published. Thus in Illinois, Forbes, Kofoid, Richardson, Shelford and others; in Wisconsin, Birge, Marsh, Juday and Pearse; in Michigan, Reighard, Ward, Hankinson and others; and in Indiana, Eigenmann, Evermann, Scott and others, have given much atten-
tion to investigations of fresh water biology which have a direct or indirect bearing upon fish culture.

In New York State, Needham, his associates and students, Betten. Johannsen, Clemens and others, working originally through the State Entomologist’s Office and the New York State College of Agriculture at Cornell University, have given much attention to life history studies of aquatic insects and to fresh water biology in general.
FISHERY INVESTIGATIONS AND SURVEYS IN NEW YORK STATE

In the East, the State of New York was one of the earliest if not the earliest to perceive the importance of fishery studies. The general investigations to which reference is made pertained mostly to lakes. In New York State it is interesting to note that nearly 30 years ago the President of the State Fisheries Commission delegated Superintendent Fred Mather, of the Cold Spring hatchery, and Bashford Dean, then assistant at Columbia College and tutor in biology in the College of the City of New York, to make an examination of the two principal bodies of fresh water on Long Island, and, accordingly very careful examinations of the physical and biological conditions of Lake Ronkonkoma and Great Pond, at Riverhead, were made (Mather and Dean, ’95). According to Bean (’09) nine years later a brief examination of two other lakes were made. “An investigation of Long Pond about eighteen miles southeast of Potsdam was made August 10th, by direction of the Commissioner. This lake is about one mile long and one-fourth mile wide. It has been stocked with brook trout in large numbers and contains a great many trout, but is overrun with suckers, and chubs, which destroy the eggs of the trout, and make it difficult to carry on their culture.

“For some years Lake Salubria, located about one mile from Bath, has been stocked with rainbow trout, lake trout and other species. It has also received some pikeperch, and it is said to contain some bass and pickerel. No trout have been caught in the lake as far as known, and it is doubtful whether it is expedient to continue the attempt of making a trout lake of this body of water.”

The first intensive study of lake biological conditions in New York State was undertaken by Birge and Juday, in 1910, when they were enabled to visit the "Finger Lakes," through a grant from the United States Bureau of Fisheries, and the month of August was spent in work upon the lakes. In February, 1911, Mr. Juday visited some of the lakes to secure winter temperatures. A week in August of the same year was used in obtaining a second set of summer temperatures. The temperatures of Skaneateles and Owasco Lakes were also taken in February, 1912, and the early autumn of that year.

The stated purpose of the investigation was to extend to these lakes the studies on dissolved gases, plankton and temperatures, such as had already been made on the lakes of Wisconsin. A valuable technical report upon the results of the work was published by the United States Bureau of Fisheries, comprising tables, graphs, analyses, correlations, and discussions of the topography, hydrography, temperatures, dissolved gases, and plankton, with accompanying topographic and lake contour maps (Birge and Juday, ’14).
No correlation of the results of this work with other conditions in the lakes has been made, and the relation to the fish forms of the lake appears not to have been considered. So far then, while of great scientific interest and value, the practical application of the results of the studies to fisheries problems, of which they are capable, remains to be made.

With the establishment of the State College of Forestry at Syracuse, a new agency concerned with the investigation of wild life of the forests and forest waters was initiated. The first publication on wild life was a study made of a worm disease of the Adirondack perch by Dr. W. M. Smallwood ('14), at that time of the State College of Forestry. In the summer of 1915 the College began a general, systematic survey of the biological and fishery problems of Oneida Lake, with the aim in view of working out a system or policy of fish culture for this lake.

Only a part of the results are yet in print. The first publication of this series was a report by Baker ('16), on the relation of Mollusca to the fish and other animals of the lake. As a result of the examination of the stomach contents of the fish, it was learned that Mollusca were a much more important element in the food of fish of this lake than could have been anticipated. Preliminary studies were made of the relative abundance of mollusks in the various bottom conditions of the lake. Baker concludes with regard to fish culture ('16, pp. 315, 316): "It is the culture of these animals that demands the greatest amount of reliable information. In the past some of the fish culture has been haphazard, fish fry and fingerlings being introduced into bodies of water without knowing whether the natural conditions were favorable or the food supply sufficient and of the right variety for their growth and multiplication. Before a planting is undertaken, it would seem the part of wisdom to know the food habits of the fish to be introduced and the general biology of the aquatic medium into which the fishes are to be placed. Thus we should know that the body of water contains plants for protection and suitable grounds for breeding, food sufficient in quantity and of the right kind, and the presence or absence of natural enemies which might seriously affect the increase of the planted fish. In other words there must be as nearly as possible a balance between the vegetation—the fish—and the food supply. Fish will be present and will persist in a body of water in proportion as the food supply is abundant or meagre and as the enemies are abundant or few in number. . . . There should be made a series of year-round observations on the aquatic life of Oneida Lake. These should be by months and should include the winter season as well as the more favorable summer, spring and fall seasons. That the fish life in the lake is more or less active through the winter season is known, but what these animals use for food is not well known."
In the introduction of the second report, having referred to foreign investigations, the author says (Baker, '18): “In America, while much biological work has been done on the qualitative side of fresh waters, few quantitative studies have been made aside from that of the plankton (Birge, Marsh, Kofoid, etc.) and a rich and almost virgin field lies before the ecologist who has the opportunity to carry on this important line of investigation. Such studies not only advance the technical or scientific side of aquatic biology but also the economic, so that both general and applied science advance side by side.”

As has been said, the study by Birge and Juday of the Finger Lakes and that by Baker of Oneida Lake are both incomplete. Each lacks the study that the other received. Among other things, the Finger Lakes need quantitative investigations of the invertebrate fish food and definite knowledge concerning what fishes, occurring there, subsist upon plankton at any stage of their life. Plankton studies such as the Finger Lakes have received are needed for Oneida Lake, for complete knowledge applicable to rational stock- ing of a lake is necessary, and particularly as concerns habits and food of young fishes.

During several years Prof. W. M. Smallwood, of the Zoological Department of Syracuse University, made observations on Lake Clear in the Adirondacks, and later published a discussion of the fish and fish conditions in the lake (Smallwood, '18).

He says that the problem which confronted him was to discover the cause or causes for the obvious failure of this lake to support an abundance of fish after thirty years of restocking. Lake Clear was regarded as typical of a number of lakes in the Adirondack region, there being in the radius of fifteen miles more than seventy-five similar ponds and lakes of glacial origin.

Concerning the food supply for fishes he says: “It is to be regretted that in this lake the number of organisms suitable for food for fishes is so limited. The result is that each species comes into competition with the other species for food. The result of this com- petition for the one abundant food, daphnia-cyclops, prevents this lake from permanently having large numbers of food fish.

“The consideration of the history of the lake, the specific habita- tion of the fish, the noteworthy dearth of aquatic plants, the actual food of the fish and the restocking that has taken place during the past thirty years leads to the conclusion that restocking has not been and cannot be a success. In estimating how many fish any given body of water will support, one must first consider the variety and abundance of aquatic plants. There cannot be any more animal food for the small fish and fingerlings than can find subsistence on the aquatic plants of any given body of water.”
After reading this description of the lake and the conditions obtaining in it as presented by Professor Smallwood, and considering the number and kinds of fish that have been planted one is compelled to agree that the lake is a very clear object lesson in overstocking. It is shown that from 1887 to 1916, both inclusive, 17,535,850 food and game fish had been planted in this comparatively small and relatively barren lake. This number comprised five species, four of which were notably predacious fishes, consisting of brook trout (683,850); lake trout (1,067,000); rainbow trout (91,000); brown trout (6,000). The largest number of all is that of the common whitefish (15,688,000). These figures were furnished by the superintendent of the Saranac hatchery.

It would appear that the most signal success as concerns the present number of fish has been with the whitefish. This is not astonishing when it is known that food stated to be utilized by all ages of whitefish is the most abundant fish food in the lake, and when the large numbers of young whitefish annually planted are considered. It is inferred that of the other four introduced species, only the brook trout now occurs, and probably it may be inferred that the stock of both brook trout and whitefish is maintained by the annual restocking, and not by natural reproduction.

While Prof. Smallwood's opinion that even more extensive plants of brook trout in the past would not have increased the present brook trout supply in the lake is quite likely correct under past and present conditions, it is more than likely that a considerably greater supply of brook trout would have been maintained if no other species had been introduced, especially providing there are natural spawning beds for the trout in tributary streams. But as Prof. Smallwood says: "It is becoming more and more apparent that we must not only know the breeding habits of the small minnows, pumpkin seeds, etc., the fry of which serve as admirable food for the food-fish fingerlings, but also the natural history of all the life of a given body of water. It is a well-recognized biological axiom that no organism can live unto itself alone. This applied to our problem means that a clear and adequate supply of water is not the only factor that must be considered in deciding to restock great bodies of water with fish fry. But rather the intricate and more or less obscure conditions that determine the sum total of life in each body of water must be taken into consideration. Such studies alone furnish a correct basis for determining the extent to which an animal may draw upon a given source of food, upon the available body of food and many kindred problems. Before the State can wisely undertake to place more fingerlings in the ponds, it ought to know whether there is enough available food to keep them at least from starving."
Fig. 22. Quaker Run, Allegany State Park. A typical mountain trout stream.

Fig. 23. Coon Run, a trout brook tributary to Quaker Run.
Fig. 24. A marshy lakeshore with heavy growth of rooted vegetation. Oneida Lake, New York.

Fig. 25. Dense cattail and water lily zone, along the swampy shore of Oneida Lake.
During August, 1918, and from June to the middle of July, 1919, a preliminary survey of the waters in Bear Mountain and Harriman Park sections of the Palisades Interstate Park on the Hudson River, was begun by the Department of Forest Zoology, and continued by the Roosevelt Wild Life Station of the New York State College of Forestry, at Syracuse, in cooperation with the Commissioners of the Palisades Interstate Park, and with the assistance of the United States Bureau of Fisheries. The examination did not cover all of the waters of the Park because of lack of time, but six ponds or lakes and two stream systems were reported upon (Adams, Hankinson and Kendall, '19). Concerning the waters of the Park the report says: “The waters present a number of unusual features which complicate the problem of fish culture more than is usually the case. The uses to which the waters of the Park are devoted are relatively more diverse than those of the usual wild waters. Furthermore the newness of the waters, having been formed or enlarged by dams, and their frequent changes of level, introduces uncertain factors which are not usually met with in fish cultural operations, and only time and further study can resolve this influence.”

This is one of the few efforts that have been made to formulate a fish cultural policy for a large forest park where the recreational and educational interests are paramount, and where the officials wished also to see the possibilities of food fish developed as much as possible. There is a very general and extensive movement for the development of parks throughout America so that we may anticipate, in the near future, the need of intensive studies of this problem.

The New York Conservation report for 1919 says: “During the last year the Commission was requested to consider the advisability of a new hatchery to be located on Lake George. It is felt, however, that it would be more advisable first to make a complete survey of the lake, and reach definite conclusions as to which of the seventeen species herebefore introduced into the lake should be propagated in the future. It is futile to expect results from a great many species. It may be possible to determine to what extent angling in Lake George is inferior to that of some other lake as to certain of the game fishes, and to determine what species of game fishes may be expected to produce the best results. Having made this determination, vigorous efforts should then be made to produce those results with the species it is decided will produce the most food and sport. This same policy should apply also to other lakes. There are other important bodies of water, much used by fishermen, which at the present time do not appear to be producing the maximum results. Illustrations are Cranberry Lake, the St. Regis Lakes, Canandaigua Lake, and some of the Finger Lakes.

“Because of the necessity of determining questions of fish planting policy, if the best results are to be obtained with the product of the hatcheries, the Commission accordingly recommends an annual appropriation of not less than $5,000 for this purpose.”

By an act of the Legislature of 1920 the Conservation Commission
was authorized and directed to make a biological survey of the waters of Lake George for the purpose of determining the most practical methods of increasing fish production. For the purpose of carrying out the provisions of this act, the sum of $2,000 was appropriated. The Commission’s report for 1920 concerning “Investigations in Fish Culture,” says: “It seems strange that, notwithstanding the fact that the United States leads all other countries in the production of fish, and that the work has been going on now for over sixty years, there are a great many problems which no one in this or other countries is able to solve or even has attempted to solve. There is no up-to-date fish pathologist in this country. No one knows positively why it is impossible to produce under given conditions at one hatchery the same amount of fish as it is possible to produce under apparently similar conditions at another hatchery. It is possible to go on and enumerate many other phases of fish cultural problems which often enter into the work of the hatcheries and which are factors in the results obtained from planting fish in streams, ponds and lakes.

“During the past year this Commission has undertaken an investigation the nature of which differs from any ever before undertaken, in the biological survey of Lake George. In this work special investigations as to the relations of plant growth to fish food were made which have suggested the importance of more extended investigations along similar lines in other ponds and lakes where the fish cultural results have not been as satisfactory as could be desired.”

In his report on the streams in Tompkins County Embody ('22) included some consideration of the principal lakes and ponds, to which later reference is made. This appears to be the first attention of the kind given to standing bodies of water by the Conservation Commission for many years. In 1922 a report upon the survey of Lake George was published by the Conservation Commission (Needham and others, '22). In the introduction Mr. Titcomb says: “Although the survey of necessity covered but a brief period of the summer months, it is probably the first and most comprehensive one of its kind ever made, embodying so many angles of investigation and having as its ultimate object the important economic problem of determining the most practical methods of increasing fish production.”

Dr. Needham’s report is not only comprehensive but delightfully comprehensible, being written in a style easily read and understood by the general reader. It is furthermore illustrated by cuts and diagrams easily followed by the lay mind. His report comprises the subjects of hydrography and environment, vegetation — including shore vegetation and free-floating microscopic vegetation, — the turnover of the lake’s vegetation into fish food, and fishes. A summary and recommendations are also given.

Mr. Juday’s report comprises limnological observations on Lake George. It covers essentially similar work as was carried on in the Finger Lakes: temperature of the water, quantity of dissolved oxygen
and of carbon dioxide, quantity and vertical distribution of the plankton, and abundance of the bottom fauna in the deeper portions of the lake.

Dr. Moore's report pertained to the primary sources of food of certain food and game and bait fishes of Lake George. She says: "This investigation has sought to determine the nature of the food taken by the young of certain food and game and bait fishes of Lake George; and with such data as a basis, to seek further information on the primary sources of their food supply."

Mr. Sibley's part in the investigation consisted of listing the species of fish occurring in the lake, with notes on their feeding habits.

Mr. Titcomb's part consisted of fish cultural observations, he devoting his time "to ascertaining the viewpoints of anglers and guides as to past and present fishing conditions and their preferences as to species to be fostered.

"Investigations were made as to the relative abundance of mature fishes in the lake, angling conditions on the principal tributary streams, and with especial reference to the abundance of landlocked salmon in streams where planted for the especial purpose of stocking the lake. Particular attention was paid to the methods in vogue for distributing and planting the lake trout after their arrival at the Lake George railroad station."

The combined report is truly an excellent and enlightening one upon work well done, what there was of it. The investigations were all too brief and incomplete for the purpose of general recommendations as concerns conservation of the fishes and stocking of the lake. The studies indicate that the waters, except perhaps some tributary waters, are well adapted to various species, but there are much data lacking which must be acquired before rational stocking or conservation can be adequately undertaken.

In his recommendations Dr. Needham asks: "What can be done at Lake George to improve the fishing?" and adds: "My suggestions fall into two groups, I: Measures Immediately Applicable, and II: Measures Looking Toward the Future." Under each of these main groups general and specific recommendations are made, only a part of which will be mentioned here as the others do not appear to demand any comment.

The second recommendation with its subdivisions is, "Give more attention to the planting of hatchery-reared lake trout and more particularly:

a. 'Acclimatize' the fingerlings to their new environment before liberating them in it. Get them accustomed to feeding on the natural food of the lake, and get them accustomed to a sight of their worst enemies.

b. Plant them in water more than thirty-five feet deep.

c. Scatter them widely in planting."

This recommendation is discussed in this paper under the subject of "Planting."

Under measures looking toward the future, the first recommenda-
tion is one well said and should be emphasized. It should have been "immediately applicable" or else the immediately applicable measure pertaining to lake trout should have been deferred to the future. He says: "Go out after more knowledge. Nothing else will serve as a basis of rational procedure. In all doubtful and difficult fish cultural practices substitute carefully planned studies for random observations and exact knowledge for hearsay. On every hand are problems in fish production with the limiting factors unknown. The cure for this condition is research."

To the present writer, the remaining recommendations and discussions of them, seem to be to the point and sound, excepting in one particular remark suggesting that the pike or pickerel is not a valuable species.

In Mr. Titcomb's introduction to these reports the recommendations, presumably derived from the individual reports, are as follows:

"1. That the planting methods for the distribution of lake trout be revised, and that they be planted as directed by the fish culturist.

"2. That the closed season on black bass be shortened so as to close October 31st."

3. [Pertains to protective patrol.]

"4. That the law for the protection of great northern pike or 'pickerel' be repealed.

"5. That anglers kill all rock bass and sunfish when caught, and if not utilized as food, take them ashore and bury them.

"6. That further efforts to stock the lake with landlocked salmon be abandoned unless some provision is made to rear them up to eight to ten inches in length."

The present writer questions the wisdom of the recommended repeal of the law concerning protection of the "great northern pike" or "pickerel," especially since the recommendation appears to be based upon general reputation and not wholly upon ascertained facts. In his general recommendations in this same report, Dr. Needham says: "Substitute carefully planned studies for random observations and exact knowledge for hearsay." (Italics the present writer's.) Yet, Dr. Needham evidently concurs in the recommendation, for which he gives the following reasons:

"The northern pike ('pickerel' of the local fisherman), is highly prized by some; but I have not included it among those I deem most worthy of propagation because of its voracious fish-eating habits. Early in life, certainly before the end of its first summer, it takes to a diet of fishes, and through later life it eats hardly anything but fishes; and it is a prodigious quantity of fish that one pike can consume in his time. The pike should probably hardly be considered an enemy of the lake trout, and perhaps not even a serious competitor; for it keeps to surface haunts and hardly invades the foraging grounds of the trout in deep water. But it certainly is both an enemy and a competitor of the shore fishes: doubtless it eats mainly
herbivorous shore fishes like shiners, that are most easily captured; but it doubtless eats the game fishes as well when it can catch them.

The chief reason for not recommending the pike is because its habits are such that no considerable increase in numbers of adults is likely to result from efforts to care for the young. It is only a sparse population of such fishes that any natural body of water can support. Grass-eating antelopes may flourish in large herds on the veldt but flesh-eating lions must of necessity have more room and be fewer in population.”

Pound for pound, the pike does not exceed some other fishes, such as the lake trout and blackbass for instance, in fish-eating voracity or capacity. In fact if "hearsay" evidence is admitted, which it shouldn’t be, the blackbass is alleged to have exterminated the pickerel in several lakes. Before taking measures to eliminate the pike, if it is indigenous to the waters of Lake George, would it not be better to "go out after more knowledge" concerning it and its natural relation to the balance of life in the lake, or in a similar lake where the balance has not been tilted to the extent that it has in Lake George, if such a body of water can be found?

The possibility of the pike being a factor in maintaining the former "balance of nature" has been discussed in another place in this paper (pp. 223-224).

Embody has discussed and made recommendations concerning the pike in Cayuga Lake (Embody, '22). He says: "Piscivorous fishes of large size must constitute an important factor in reducing the fish population in any small body of water. It is well known that the larger the individual fish above a certain weight, the more slowly it grows and the more food it requires simply for maintenance. It cannot be considered an economical practice to maintain a few giant fish at the expense of a large number of smaller ones. This is exactly what we are doing in permitting monstrous pike to simply maintain themselves where a large number of smaller fishes would grow and thus increase the amount of fish flesh.

"It is believed that there are many large pike from ten to twenty pounds in weight, in Cayuga Lake. One pike of thirty-seven inches, weighing nineteen pounds, had in its stomach a pickerel of eighteen inches and one and nine-tenths pounds in weight. It had consumed at one meal fish flesh equal to ten per cent of its own weight. It would not be an underestimation to say that no more than twenty pike of over eight pounds are taken in one year. The average size of those generally caught ranges from twenty to twenty-five inches long and from two to four pounds in weight. If all pike over twenty-eight inches long and weighing five pounds were eliminated, there would undoubtedly be more of the average size pike and certainly more of the other species of fish particularly yellow perch. It seems to the writer that for Cayuga Lake it would be much better for a number of fishermen to be able to make a number of catches of moderate-sized fish each year than for one or two fisherman only to be able to catch a very few giant fish.

"For this reason it is believed that the large pike which are sel-
dom captured by angling should be taken out by commercial fishermen and put on the market as food for the community. If all pike over twenty-eight inches long were so captured there would undoubtedly be many more pike even above the average size, enabling the pike fisherman to better satisfy his desire for angling. It is known that pike first spawn when eighteen to twenty inches long and about three years old, therefore, a pike of twenty-eight inches will have spawned at least once and more probably twice or even three times, before it is large enough to be taken commercially."

Without considering the question of the practicability of regulating the size limit of the pike in the commercial fishery, it may be said that some of the points stated in favor of the recommendation are well taken. There may be a question, however, concerning the number of large pike in the lake. If they are very numerous why are not more of such "voracious fish of prey" taken by anglers?

It is a well-known fact that the proportion of overgrown fish to those of smaller sizes in any body of water is always small, and their number depends in great measure upon the extent of waters suitable to the species.

It may be true that the smaller fish of the pike family, and particularly yellow perch, would increase in number, but it may be a question as to the effect of such increase on the balance of life in the lake. Isn’t it possible that increase in number of perch may result in decrease of some other organism upon which some other valuable fish depends for its maintenance — even the pike itself? It is quite possible that the value of the very large pike in the economy of the lake if it has any, is in the reduction of such forms that devour the food of young pike. But it is also commonly accepted as a fact that the very old fish are inferior in reproductive capacity, notwithstanding the large number of eggs produced. It may be that the elimination of the old fellows would give the younger breeders an advantage which would result in an increase in number and in better conditioned pike. However, this is all speculation, and speculation in this instance at least, except to indicate the necessity of investigation, is rather futile.

As concerns the Lake George pike situation Embody’s suggestion applies only in reference to the size of the pike. It appears that at present the very large, old pike do not exist there, and those still found are comparatively small. So the big pike factor is eliminated at least for a few years.

Mr. Titcomb’s reasons for his recommendation are stated as follows:

"The pike of Lake George, locally called ‘pickerel,’ is the great northern pike which occasionally attains a weight of thirty to forty pounds, but in Lake George a weight of twenty pounds would be very rare. Tarleton H. Bean, in ‘Fishes of New York,’ mentions individuals of sixteen and seventeen pounds, and tells of more than thirty examples averaging in excess of ten pounds, each of which was taken from the waters of Lake George during the season of
1889. He adds, 'The pike is a voracious fish and destroys everything within its reach in the form of animal life; other fish, water birds, and mammals are consumed in enormous numbers. From its concealment, like a beast of prey, it darts out suddenly on its victims and seldom misses its mark.'

"Dr. Needham's report confirms these observations. It is believed that the pike consumes twenty per cent of its own weight in fish daily. It is a prolific breeder, producing according to its weight anywhere from 50,000 to 600,000 eggs."

"Spawning takes place soon after the ice leaves the lake at which time the large pike may be seen lying close to the surface over a shallow weedy bottom."

"It is contrary to general practice to afford protection to northern pike in waters inhabited by lake trout and black bass, but some of the guides stand for its protection, and assert that neither bass nor lake trout are found in the stomachs of pike when caught. The writer is of the opinion that the pike destroys many smallmouth bass, and may be very destructive to the lake trout in winter when both species are inclined to extend their range. It undoubtedly is a factor in the decimation of the bullheads."

"In view of the foregoing it is perhaps fortunate that an epidemic has been raging among the pike, an epidemic said to have reached its height in 1919, when the number of dead pike found floating upon the surface of the lake was very great."

"It is recommended, that in view of the reputation of this fish, a modification of the special closed season on pike have consideration; or better still, that laws for their protection in Lake George be repealed."

Mr. Titcomb's reference to the egg-producing capacity of the pike is misleading, and Dr. Needham's description of the natural life-cycle of a generation of lake trout is particularly pertinent in this connection:

"Nature's method of propagating a species is indicated in our diagram, fig. 22 [not reproduced]. Here is seen a pair of adult fishes, be they lake trout or any other sort; it is the same for all. They produce a vast number of eggs, many of which are lost, while others hatch into fry. The fry are set adrift in a rough world in the midst of enemies and competitors, and many of them are killed or eaten, but some survive and grow to be fingerlings. So the process of elimination goes on, ever fewer attaining to larger growth, until at last two survive and lay eggs for another generation. The number of young produced is proportioned to the vicissitudes of life; there are only enough to insure the continuance of the species under natural conditions. This is what is known as the natural balance. It is one of the marvelous phenomena of the living world. It is true of every species in wild nature. There may be occasional ups and downs; but if we consider how things go through a series of years, we can readily observe that there are about as many individuals of any wild species through one decade as through another."
This means that any two parents, despite the large number of their eggs, succeed in leaving on the earth but one pair of descendants that in turn reproduce."

From this it is seen that the fact that the pike produces a large number of eggs indicates that there are many natural adverse conditions operating against the species. The fecundity of the pike is a provision to offset them. Then, too, the natural longevity of the pike in addition to the capacity for egg production indicates that the vicissitudes of the pike race, notwithstanding the reputed voracity and savageness, are something prodigious. This being so suggests that when disturbances of balance occur, the advantages are likely to be on the side of some other factors or elements in the pike's habitat rather than on the side of the pike.

A "general practice" in the past, as concerns pike or any other fish, is hardly sufficient reason to condemn or favor it. Titcomb's opinion that the pike destroys many small-mouth blackbass appears to be supported by no evidence, and there is at least presumptive evidence that the blackbass may destroy the pike, as other reputed victims of the voracity of one species of pike have been observed to do. Brook trout have been known to take young eastern pickerel and the common chub or fallfish have been found feeding ravenously upon young of the same species (Kendall, '18).

Referring to the recommendation concerning rockbass and sunfish, both of which appear to be indigenous to Lake George, it would appear that the rockbass at least is a food fish of some value, although Needham omits it from his enumeration of the most valuable species of Lake George.

In the discussion of the fishes of Lake George, Titcomb says: "The rock bass and two species of sunfish are very abundant about the shores of the islands and mainland. They are easily caught, and furnish much sport for the little folks and for unskilled anglers. [Italics are the present writer's.] Properly prepared, they are good table fish, either in chowder, cooked in the frying pan, or over the open camp fire. Many people do not care to skin and dress them and therefore throw them back. It is a practice of the anglers fishing for bass to return the rock bass and sunfish of which they catch perhaps six or eight for every bass they are able to kill. This practice is upsetting the balance of nature. In other words these fish which are rather objectionable in lakes of this character are being protected when the other more desirable fishes are being removed. It is better to kill them, and if not utilized as food to take them ashore and bury them."

To the present writer, the advice given in the last lines of the above paragraph and in the recommendation, appears strange, coming as it does from a fish culturist and conservation advocate. It is admitted that the rockbass is a good food fish. Bean ('03) says: "The rock bass bites very freely and is a fair game fish and excellent for the table." It is not shown in what way the balance of nature is being
upset by failure to destroy the rockbass and sunfish. It does not seem to be a good policy to destroy those fishes just because the skilled angler catches more of them than he does of the fish he seeks. It is possible that "Nature" is already somewhat out of "balance" in Lake George, and that undue destruction of those fishes will effect still greater derangement. It surely is not good conservation to destroy one good food product because another is less plentiful or declining, especially when it is not evident that the comparatively smaller number of the one is even indirectly attributable to the other.

Considered from the sport fish standpoint, the question here arises: Are not the "little folks" and "unskilled anglers" to have any consideration? Are they to be deprived of the pleasure of catching fish because the "skilled angler" is not getting full satisfaction in his pursuit or because he is annoyed in that pursuit by some fish which he does not desire? The object of conservation of game fish is not only to provide the present but the future generations of anglers with game fish. If the "little folks" of the present generation can't attend the school afforded by their favorite fish, who will compose the future class of skilled anglers? We may go still further and ask whether the man who is equipped with a split bamboo rod, artificial flies, wading boots, and a pocket flask, is more an angler than the drowsy colored g'man provided with a cane-pole and bob as he awaits the bite of a "cat," or "brim"? Or is the portly gentleman trolling a line from the stern of a boat rowed by a sturdy guide, more an angler than the barefoot boy with his elder pole, whose sport is afforded by sunfish and minnows?

"O what are the treasures we perish to win,
To the first little shiner we caught with a pin?"

Are the interests of one class more important than those of another? Moral philosophy says: "No." Actual practice says: "Yes." Even so, in actual practice the problem always exists as to where to draw the line between the two classes of fishers and fishes.

The earliest biological examination of a stream in New York State of which there appears to be any account is that of Caledonia Creek, made over 45 years ago. A report upon it was made by Dr. J. A. Lintner ('78), State Entomologist. In the same publication Professor Peck reported upon the plants of the creek. Thirty years later, according to Dr. T. H. Bean, late State Fish Culturist of New York ('08), an examination of two streams was made concerning which he says: "At the request of Mr. F. C. Westfall of Oneida, an examination was made of two streams in the vicinity of Oneida, the Cowassalon and Skenandoa, with reference to their capacity for sustaining trout. The Cowassalon was found to be admirably adapted for brook trout and the Skenandoa for brown trout. Specimens of the natural food found under the stones were taken to the office and identified."

In 1915 the State of New York began the work of studying the streams of the state with the stated purpose of developing proper working plans for their systematic stocking, on the ground that the
products of the State's eleven hatcheries, representing an annual commercial value of over $200,000.00, be distributed and cared for in such a way as to insure the maximum return for the money and labor expended.

Concerning the proposed study, Dr. Bean wrote ('16): "In order to devise more intelligent and effective methods of stocking and protection, based upon a thorough knowledge of the actual conditions obtaining in the streams and lakes, the Commission has undertaken an intensive investigation of the waters of the State. Some of the principal subjects for investigation are the following: the distribution and habitats of the fish found at present in these waters; their food habits, as determined by analysis of their stomach contents; the supply of natural food available, such as insects, mollusks, crustaceans, worms, and aquatic vegetation; the spawning seasons of the various fish; their natural enemies; stream pollution and methods of controlling it; proper open and closed seasons; methods of cooperation between the Commission and associations and individuals interested in propagating or protecting fish. It is confidently believed that this investigation will lay the foundation for a marked increase in the quantity, as well as for improvement in the quality, of the fishing in New York State."

The Sixth Annual Report of the Conservation Commission for 1916, says: "In the last annual report attention was given to the importance of making working plans for stocking the fishing waters of the State, in order that the waste of the product of the state hatcheries, which has gone on heretofore [italics the present writer's] after the fish have left the control of the state, might be checked. During the spring and summer and part of the fall two men, of the proper scientific attainments, were engaged upon such a study of the running waters of Oneida County. In this county alone there are approximately 2,000 miles of running streams, all of which were covered during the season with as much thoroughness as was necessary for the purpose of laying down working plans. The adaptability of the various streams for different kinds of fish was investigated, scout work to determine the proper planting points was done, and other data necessary for developing those streams to their highest efficiency as fish producers were obtained.

"These data include such facts as the degree of pollution, the temperature of the water, the food supply for fish life, the extent to which the streams are fished, and the local agencies that are available for carrying on the stocking. It was discovered that while some very fine work is done in certain sections, other large sections of the county have been totally neglected as far as fish stocking is concerned. At the same time the drain upon the streams, because of the increased use of automobiles has reached a point where they have become practically fished out. The results of the study of Oneida County are being embodied in a report to be published shortly. Systematic stocking in accordance with the plans given in the report will then be undertaken. This study opens a new field
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in fish culture and one which New York, with its large annual expense for fish hatching and rearing, could not afford longer to neglect."

The Conservation Commission report for 1917 says: "The stream survey of Oneida County, which was undertaken two years ago upon an experimental basis, has been completed and the results have been published in a bulletin and distributed largely throughout the county. This is the first time that the Commission has had available complete and absolutely accurate data regarding stream conditions over any large area. Strange as it may seem, the state has been shipping millions of fish for public waters without having authentic information regarding the suitability of those waters for the fish shipped. It is believed that the intensive study of Oneida County and the working plans that have been evolved as a result of this study will eventually overcome this difficulty for that one county. It is the intention of the Bureau of Fish Culture to obtain similarly reliable information as rapidly as possible for all of the State's public waters. This is absolutely necessary if hit or miss methods in fish planting are to be avoided, and if the efficiency which has already been developed in the hatcheries is to be extended to the streams."

The Conservation Commission report for 1918 briefly reviews the previous work in this direction and adds: "During the past summer a survey was made of Tompkins County by Prof. G. C. Embody of Cornell University, assisted by one of his students; and a full report on that county is in the course of preparation. Efforts were made to obtain men qualified to make surveys in other counties, but they were found to be practically unobtainable. The training required for this work is possessed by very few men and those who might otherwise have been obtained were engaged in war work. It is hoped that arrangements may be made during the next season to undertake surveys of the waters of other counties."

"So far only the running streams have been covered, because of the long time and special equipment necessary for lakes. It is desirable to undertake this work on the lakes as rapidly as possible, for the purpose of making them most productive of the species of fish best suited to them."

In the Conservation Commission report for 1919, reference was again made to Embody's survey of the streams of Tompkins County concerning which the report says: "Inasmuch as many of the streams have their sources in adjoining counties, it seemed advisable to complete the survey of the adjoining watersheds in other counties. This work has been done during the past summer under the direction of Prof. Embody, who was unable personally to give a great deal of time to it, but directed the work of the two assistants who worked in conjunction with him the previous year."

In 1917 the Conservation Commission published its survey of Oneida County streams by Clemens ('17). The following are stated to be the main points investigated and reported upon:

1. Source, length, width, depth and water into which each empties.
2. Character of the bottom.
3. Rate of flow.
4. Color and transparency of the water.
5. Vegetation in and along the stream and amount of shade provided.
6. Character of the surrounding country—whether timbered or open land and whether the stream is likely to be subject to drought, severe floods, or the inflow of a large amount of sediment from the watershed.
7. Temperatures from source to mouth.
8. Headwaters and spring tributaries were located as possible planting points.
9. Obstructions to the migration of fish.
10. Points at which pollutions occurred and the character, amount, and general effects of the pollution.
11. Presence of pools and side holes as places of shelter for fish.
12. Streams or sections of streams posted, and by whom.
13. The quantity and variety of food organisms for fish in the stream.
14. The kinds of fish present.
15. A few fish were taken from each stream for future stomach examination, in order to obtain more accurate data on the natural fish food.
16. As much local information as possible was obtained regarding the extent to which a stream is fished and the agencies available for carrying on systematic stocking and development.

After a discussion of the "broader issues," "working plans" are suggested, and detailed recommendations for streams follow. The specific recommendations are very brief, consisting principally of a statement of their fitness or unfitness for fish and the kind of fish to be planted in any instance.

It was not until late in 1922 that Embody's report upon Tompkins County was published. His report covers not only the streams but also to some extent the lakes and ponds. General conditions are discussed and more detailed consideration of each body of water is given than is the case in the Oneida County report.

Concerning "Brook Trout versus Brown and Rainbow Trout," Clemens ('17) says: "It has been proved conclusively that brown trout are very destructive to native brook trout. Hence in the working plans following, brown trout are recommended for only those river systems in which most of the water is no longer suitable for brook trout and where conditions give little promise of improvement in the near future. It is important to take the entire river system into consideration, and not merely individual streams, for brown trout planted in one stream in the system will in time work into the other streams, unless prevented by dams or other obstructions. Rainbow trout prefer large bodies of water and show a tendency to work down from the upper streams into the lakes and larger streams. They are somewhat destructive to native trout and
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should not be planted in brook trout waters. Because of these facts, there are but few waters in Oneida County in which it is advisable to plant rainbow trout.”

Concerning these same species, Embody says: “It is believed that of the three trout the brown trout is the most predacious and most destructive of other fish and it is often stated that if a stream is stocked with all three species, the browns will eventually exterminate the others. There are many streams where brook trout have disappeared or become greatly reduced in numbers a few years after the introduction of brown trout, but it has in no case been proved that brown trout has caused the trouble. In fact there are streams in Tompkins County where the brook trout and brown trout occur apparently in equal numbers and have lived so for a number of years. The Van Pelt Brook is perhaps the best example. This matter is important enough to merit investigation. But until something more definite is known, it is well not to take any risks and those who have studied the question deem it wise to keep the coolest and purest streams for brook trout only, except in some cases where rainbows may be advantageously introduced.”

Embody discusses also other stated habits of the brown and rainbow trouts, but it does not appear to have occurred to either Clemens or Embody or their predecessors in trout study, that real incompatibility might be indirect rather than direct. Given three individuals of the same size, one of each species, it may be a question which is the most “predacious.” From the statements of some “authorities” it would appear that the advantage on the part of the brown trout is due to the large size it attains (figure 21). Within its natural growth limitations the size attained by any fish is in a great measure dependent upon the quantity and quality of its food supply. It is axiomatic that any stream can provide only a certain amount of animal life. It has been claimed that the optimum of favorable conditions for the three species in question differs somewhat, but these favorable conditions seem to overlap. Given a body of water of optimum favorable conditions for one of the species but which the other species nevertheless find congenial, might it not be reasonable to expect that the first mentioned would ultimately crowd out the others, not necessarily because it eats the other two forms but because under optimum conditions it is a competitor of greater capacity for the food supply? This might and probably would, in some cases at least, react upon this fish itself in that during the period of competition it is deprived of more or less food, but such reaction would again be relieved if the fish were driven to eat the other species, or if the other species were driven out. Then the natural food supply could be expected to again increase to a maximum. This situation might exist in connection with any one of the three species mentioned. As Embody says, it merits investigation. However, to the present writer’s mind the point is that no more than one species of the trouts should be planted in the same place. If a stream possesses optimum brook trout conditions in one part, optimum
brown trout in another and optimum rainbow trout conditions in another, and if the optimum conditions of one are unfavorable to the others, it appears logical to believe that each species would seek the portion of the stream in which the most favorable conditions occur, and that the tendency would not be to an extensive invasion of the domain of the others.

Both Clemens and Embody have made recommendations for planting the fish which conform to a great extent to this idea, although apparently for different reasons.

After all, the fact is that speculation does not decide any question and there is still need of just such commendable investigations as those conducted by these two biologists, but they should be extended to other waters and include a thorough study of the habits of the fish themselves. Until this is done, as Embody remarks in effect, it is better to play safe.

The Conservation Commission report for 1918, in connection with the subject of "Stream Study," says: "So far only running streams have been covered, because of the long time and special equipment necessary for lakes. It is desirable to undertake this work on the lakes as rapidly as possible, for the purpose of making them most productive of the species of fish best suited to them."

In 1920 a fish survey of waters in western New York, by the Roosevelt Wild Life Forest Experiment Station, of the New York State College of Forestry at Syracuse, was begun, in cooperation with the Erie County Society for the Protection of Birds; the Buffalo Society of Natural Sciences; the Springville Rod and Gun Club; the Boston Valley Fish and Game Club; the Cazenovia Valley Fish and Game Conservation Club; and the Akron Forest, Field and Stream Protective Association. The work was confined largely to streams of Erie County, but some attention was given to a few waters of Niagara and Genesee Counties.

In 1921 a preliminary reconnaissance of the streams in Allegany State Park and vicinity was started by a party from the Roosevelt Wild Life Forest Experiment Station, under the immediate direction of Mr. T. L. Hankinson, Ichthyologist of the Station.

Concerning the work, Mr. Hankinson says in his report (not published): "Such a short time could be spent at the Park in 1921, and so much ground had to be covered in this preliminary reconnaiss ance that little could be learned of the fish of the region. The data in this report, then, can be of value in connection with those to be obtained later, but they are insufficient for any important or definite recommendations for a fish policy for the park or for any body of water in it."

Collections of fish, other aquatic vertebrates, and aquatic invertebrates were made; photographs taken of all the places where collections were made and with every collection a record was made of the following: locality, date, weather, air and water temperature, rate of water flow, depth, character of the bottom, clearness of the water, vegetation of the shore and stream bed, vertebrates associated with fish, etc. Collections were made in the following streams:
Allegheny River, Great Valley Creek, Little Valley Creek, Quaker Run system (figures 22, 23), Red House Creek and Wolf Run. Twenty-six species of fish were collected, including three game fish, — brook trout, rainbow trout and brown trout.

Brook trout were recorded as abundant in the Quaker Run system and a few were found in Wolf Run. A few rainbow trout were found in Quaker Run, also a few brown trout, but the latter were said to be common in Red House Creek.

In August, 1922, a continuation of this Allegany State Park survey was made more intensively by the examination of the Quaker Run system by a party from the Roosevelt Wild Life Forest Experiment Station, under the immediate direction of the present writer. The aim of this survey, as in the case of that of the Palisades Interstate Park, was to work out upon a broad basis a general fish cultural policy for the Park. Quaker Run was examined from near its source down to the Park Headquarters. All of the tributaries with the exception of Coon Run were explored, most of them from their source to their junction with Quaker Run. The streams were carefully examined in sections, each day a different section, and detailed notes were made of the character of the streams and immediate banks. Collections were made of the fishes and aquatic invertebrates, with the aim of determining the abundance and distribution of the various species of fishes, and the quantity of food for trout. A rough survey was made of the dimensions of each section and an effort was made to count the trout in each section, to which census the clearness of the water and openness of a greater part of the stream lent itself beautifully. In Quaker Run, brook trout were found from the extreme upper limit of examination down to the beginning of the open country just above "headquarters," and in all the tributaries throughout. Only two adult brown trout and one fingerling were seen, and only a few small rainbow trout were observed in Quaker Run and these in the lower sections.

This appears to be the first time that an actual census of trout of an entire stream has been attempted. It is believed that a fairly accurate count was made, and they were roughly classified by estimated lengths as: fingerlings; large fingerlings; 4-5 inch, 6-7 inch, 8-9 inch, 10 inch trout; and up. Probably there are but few places so admirably adapted to such work as in these brooks. It was hoped that it would be possible to correlate the number of fish observed with the numbers planted in different years, but the information concerning the number planted was found to be unreliable. However, if accurate records are kept of future fish plantings another census would be of interest and value in relation to stocking and maintaining the fish of the streams, and particularly as concerns the capacity of the streams to support trout of any kind. This information would serve as a guide for recommendations as to kinds and numbers of trout to plant in the various waters.
GENERAL PRINCIPLES OF STOCKING INLAND WATERS

As pertains to stocking or restocking of waters, there are a number of essential ecological conditions that require attention. It is desirable to know not only to what kinds of fish a body of water is suited but also how many of each kind it can sustain, maintain and retain. Its sustaining power in a measure depends upon the quantity and quality of the food supply; that of maintenance depends upon the perpetuity of its food supply and upon adequate breeding places, or annual plants of fish; the number that can be retained depends upon the habits of the fish, intercommunications of waters and the control of the fishery. One of the essential conditions to consider, then, is biological capacity.

Food Producing Capacity of Fresh Waters. It has been long known that the fry of a great number of fishes feed upon minute Crustacea and small insect larvae which live in the water. Because of this relation, for many years it seemed that the solution of fish culture depended to quite a degree upon our knowledge of these small organisms, both plant and animal, which floated about in the water, the plankton. This stimulated many quantitative studies of the plankton in the Great Lakes and other smaller ones by Reighard. Ward, Birge, Marsh, Juday, and others, particularly in the lakes of Michigan and Wisconsin. Kofoid made an extensive study of the plankton of the Illinois River ('03, '08) and his investigations, among other conclusions, led him to believe that the submerged aquatic plants were a vital factor in the production of plankton; the more abundant this vegetation, the less abundant the plankton. Pond ('05) later modified this conclusion and showed that the amount of plankton, other things being equal, is in an inverse ratio to the amount of its gross non-rooted vegetation, and in a direct ratio proportional to the amount of its gross rooted vegetation (figures 24, 25). He concludes as follows (p. 525): “If we accept the conclusions reached in this paper that gross rooted vegetation is favorable to plankton production, and if we further accept the current argument that fish production is dependent on plankton production, the practical applications of the results of this investigation are simple. In the stocking of ponds for fish culture care should be taken to have a good soil for the bottom; not a stiff clay nor sand, but a good loamy soil, such as is favorable for land plants. The species allowed to grow should be those which are known to possess roots and to be very dependent upon the soil, such as Vallisneria spiralis, the so-called eelgrass, and Potamogeton, or pond weeds; not forms without roots, such as Ceratophyllum, or those less dependent upon the soil. In natural lakes choked with a growth of Ceratophyllum, the removal of this form and the substitution for it of rooted plants offer possible means of increasing the supply of edible fish.

“The poverty of the Great Lakes in plankton may be attributed to several causes. One of these is, doubtless, the relatively small shore area in these waters occupied by rooted aquatics. The com-
Fig. 26. Swarms of mayflies, Oneida Lake, New York. An example of surface fish-food, at times remarkably abundant.

Fig. 27. Caddisfly cases, along a brook in Palisades Interstate Park; an example of bottom fish-food.
paratively short shore line, the narrowness of the shore area, and the mechanical action of the waves, all tend to limit the growth of rooted plants, hence to limit the productive capacity of the lake in plankton and, according to the current belief, in fishes."

But in addition to the minute animal food in the water the older fish in general require still other food materials, such as the gross forms living on the bottom. Investigations of their character were long neglected, so that it remained for F. C. Baker ('16, '18) of the New York State College of Forestry, to take up this subject in a quantitative way in his investigation of Oneida Lake. Baker's studies showed very clearly that 88 per cent of the gross invertebrate population, or fish food, was found upon the bottom within the six-foot contour line. It was also found that life was most abundant in sand and the poorest upon boulder bottom. These were the first investigations of the kind in America. About the same time, somewhat similar qualitative studies were made in Lake Mendota, Wisconsin, by Muttkowski ('18), and very recently the Mollusca have been studied in Lake Nipigon in Canada by Adamstone ('23). The only similar European study was made in Sweden in Lake Vättern by Ekman ('15). (Cf. Baker, '18, p. 252; also Clemens and others, '23, pp. 171-188.)

Thus, these studies of the minute and gross fish food (figures 26, 27) in the waters will serve as a foundation for future studies which aim to determine the fish food producing capacity of our inland lakes and streams. Such studies must be extended and intensified before we have a really adequate basis for fish culture in public waters.

We now need intensive study of the habits of the young of all our important fish, in order to know their normal haunts and food as correlated with the normal food supply in our lakes and streams. As Baker ('18, pp. 208-218, 224) pointed out in his study of Oneida Lake, one of the next important steps will be to determine the amount of fish food which fish need for definite periods throughout life. Until this information is secured, as well as the amount of food which a given water can produce, we will remain in the position of a farmer who does not know how much pasture he has or how many cattle he has to pastured.

**Breeding Grounds.** Not only must fish have proper food and proper physical and chemical conditions of the water in order to maintain themselves, but for permanent maintenance there must be available suitable conditions for breeding. The breeding conditions and habitats vary greatly for different kinds of fish. Some deposit their eggs upon gravel shallows in rapid streams, some upon rocky shoals or bars, others upon quiet sandy or gravelly bottoms, and some among vegetation. The great majority, however, breed in shallow waters; and it is in such conditions that as Baker has shown for Oneida Lake we find the greatest abundance of fish food. This is a significant indication of where certain species of lake and pond fish should be planted.
The character of the breeding grounds may be changed or destroyed in many ways. Sand, soil and other materials, such as sawdust and other débris, may be washed upon the breeding grounds and thus make them unfavorable. Severe erosion may clog the channels of streams and destroy the breeding grounds as effectively as a driftwood dam or a beaver dam may destroy a shoal or riffle in a brook or creek. Even the growth of vegetation upon the breeding grounds may injure them, although some fish will clear away such plants when they form their nests.

When periodical planting is intended to wholly replace natural breeding conditions of course the breeding habitat is correspondingly reduced in importance, but on the whole this is a very expensive policy and is of very doubtful applicability to public waters. Otherwise, provision for such grounds and their protection is of the greatest value. The changing conditions of these grounds, and the life of the eggs and fry while upon them, are in urgent need of very careful study. Today this is one of the weakest points in fish culture.

Relation of Volume of Water to Capacity. It is not necessary to call attention to the possibilities of depletion from unrestricted fishing by an unlimited number of anglers. "Artificial" propagation and due regard to conservation greatly reduces the danger. Yet there is a limit to the efficacy of artificial stocking of waters imposed by the limitations of biological capacity, the significance of which is that it is possible to conceive of so many anglers that the waters could not support enough fish to afford good fishing to all; also that there would be danger of overstocking in any attempt to meet the demand, which sooner or later would result in general depletion. Of course there is at present no generally satisfactory way to limit the number of anglers in public waters, and the customary limits in size and quantity of fish and in angling methods are about the only feasible restrictive measures. This point, too, involves a consideration of biological capacity. Amongst other considerations biological capacity involves the volume of water and its physical characters, as waters differ not only in respect to the number of fish they can support, but in the kinds of fish to which they are suited and the size to which the fish can attain in them.

In respect to volume and physical characters bodies of water differ greatly. There are standing bodies of water comprising lakes, ponds, pools, springs, etc., and moving waters designated as rivers, streams, creeks, brooks, runs, etc., and there are waters also which may be regarded as more or less intermediate between the two classes. Many of these contribute to one or the other both physically and biologically. All of these conditions should be taken into consideration in stocking, for success or failure may depend upon one or another of the characters.

Lakes and Ponds. Recent terminology affords no definition to distinguish a lake from a pond. Webster's Dictionary defines a lake as "A considerable body of standing water in a depression of the
Roosevelt usually is marsh. It becomes a pond; when the pond is mostly filled with vegetation it becomes a marsh. Lake basins have originated in many ways, but mostly through glaciation. A pond is defined as "A body of water naturally or artificially confined and usually smaller than a lake; in England, usually, except locally, a body of water artificially confined."

In some localities comparatively large bodies of water which used to be called ponds are now lakes, and the name lake is often locally given to inconsiderable "bodies of standing water in a depression in the land." The largest inland body of water in Maine, Moosehead Lake, has always been known as a lake, but the second in size, now Sebago Lake, was once "Sebago Pond." A small body of water near Portland, formerly "Duck Pond" is now "Highland Lake." Thus the terms lake and pond have become quite generally synonymous, and in this discussion they must be so regarded.

Lakes and ponds vary greatly in character in different sections of the country and often in their different parts (figures 28, 29). In the northeastern states the majority of "considerable bodies of standing water in a depression of the land" are glacial and post-glacial in origin. In many respects, although greatly differing in size, they are very similar in character. There are also variable extents of river expansions, as well as considerable bodies of water set off from a river, lagoon-like in situation but too large to be called lagoons, that have been termed lakes.

While this paper does not aim to include artificial ponds in its discussion, reference should be made to certain bodies of water of variable size and character which perhaps may be called semi-artificial ponds. For those who desire information on artificial ponds reference should be made to Embody ('15), Johnson and Stapleton ('15), and Titcomb ('23). Ponds of this kind are those which have been formed by damming a stream (figures 30, 31), but which have developed into or remained in a more or less wild state, such as some millponds, water storage reservoirs, ice ponds, or beaver ponds, or they may have been originally intended for fish ponds. They vary in size and character according to circumstances, and in general may be much like some other natural ponds. Some well-known lakes and ponds were thus formed or increased in size by having been dammed by the action of ice or floods in glacial or post-glacial times. These, however, are all under the head of natural lakes and ponds. The history of all recent semi-artificial ponds subsequent to the formation of dams has been much the same, depending upon the obtaining local conditions. Nearly always the result has been more or less rise in the temperature of the water. Often water plants accumulate in shallow water, and always there is a gradual accumulation of silt and débris in shallow water at the mouths of inflowing streams which gradually encroach upon the depth of the pond, so that sometimes the bottom thus formed rises
to the surface as “floating islands” (figure 30). Many small ponds have been filled with such accumulation and become mere frog ponds or even quaking bogs. The outlets of lakes or ponds of such character are almost always lowered to such extent that they are practically dry in summer.

In time the animal life of these ponds, particularly the lower forms, also increases in quantity and changes in character. But unless by the instrumentality of man the fish life has seldom been changed in character, although it might be in quantity in one way or another.

The kinds of fish suitable for such ponds vary with the character of the pond, as in the case of natural ponds. So in stocking the physical and biological conditions must be ascertained just as in the case of natural ponds. In restocking, guidance may be provided by a knowledge of the original inhabitants, but as in the case of natural ponds, this is not always a safe criterion, for the pond may have greatly changed since it was occupied by the original stock, and even the original stock may have existed only by tolerance and perhaps in much smaller numbers than some new forms would provide. So as in the case of natural ponds, each sort of pond furnishes its particular problem.

Streams. The term stream is a comprehensive one, even when restricted to water courses. A river, brook, creek, run or rivulet, is a stream. But among our common names for streams there is no definite rule to enable us to distinguish by name a river from a brook by the size. Webster defines a river as a natural stream of water larger than a brook or a creek, and brook as a natural stream of water smaller than a river or creek. The creek is an inland stream, stated to be smaller than a river, larger than a rivulet or a run. A rivulet is “a small stream or brook; a streamlet,” and is synonymous with rill. A run as applied to streams is “a brook, a stream, a watercourse.” Thus only in a general way does the dictionary enable us to distinguish one from the other. Common usage also is about as obscure.

Few streams are relatively non-fluctuating in volume through the different seasons (figure 33) or uniform in character throughout their course, and therefore vary more or less in suitability or capacity for any one kind of fish. Such variations may be permanent or temporary. Permanent variations in a measure determine the fish fauna of the different areas. Thus only one or two species may occur in the upper and several in the lower waters, as for example brook trout in the upper portion and pickerel and suckers or other species in the lower section. Then again a stream is often interrupted by rapids or riffles and intervening still water sections, as so-called “dead waters,” and pools. Such localities often afford the occasion for seasonal movements of fish for breeding, feeding or safety.

Temporary variations are such as are caused by seasonal changes (figures 32, 34, 35), as in height of water, temperature, etc. These variations may also be the occasion of more or less migratory movements of the fish inhabitants of the stream or a section of it.
As concerns game fishes and their relation to their physical and biological environment, while lakes and ponds in some ways and in some localities may be considered as distinct, in other ways and in other localities they are intimately bound together and cannot be considered otherwise in connection with certain fishes.

There are some fishes which pass their entire life in a lake or in a stream, at no stage of their existence migrating from one to the other. Again there are others which pass a part of their life in the lake and another part of it in a stream. Certain primarily lake fishes enter streams to breed, and cannot successfully breed elsewhere. The young of some of these pass their early life, which may be from a month or two to a year or two, in the stream. The young of still others almost immediately after hatching either actively or passively enter the lake. Still others which are hatched in a lake soon after birth make their way into streams. In some streams phenomena similar to those mentioned in relation to lake and stream are observed in the relation of the larger stream to its tributaries. So in planting fish in lakes or streams it is essential to know what their habits are in this respect, for upon that knowledge successful stocking to a great extent depends.

The relation of lake and stream or large stream to smaller stream, however, is not restricted to propagation and young fish. Some fish enter tributary streams from a lake or large stream as adult fish for other reasons than that of propagation. It may be for food, or it may be for some other reason, as temperature, for instance. The sojourn in these tributary streams is more or less temporary. For example, there are known instances of brook trout leaving a lake and appearing in considerable quantities in a tributary stream where they remain for some time, then disappear, and absolutely no trout of any size can be found there. Still other instances, capable of definite citation, are those where large trout occur and remain in the lake and never ascend a stream, unless to spawn, and sometimes not even for that purpose. But small trout up to ten inches or so in length ascend the brook in the spring, or summer, during stages of high water in the brook and return to the lake when the water of the brook subsides, or warms up. Sometimes also, while large trout spawn in the lake, smaller trout ascend the streams for that purpose and remain there all winter, returning to the lake in the spring or summer.

**Suitability of Waters for Fish.** A utopian wish of the fish culturist is for a simple method by which he can determine the favorable localities and conditions in which to plant fish. The oldest method is similar to that of the pioneer farmer who in the virgin forest chooses the land for his farm by selecting the land with the best forest. He assumed that, generally speaking, the best soil produced the best timber. The fish culturist has tended to assume that waters already having thriving fish are favorable waters. This method still remains the most practicable for remote or inaccessible waters. In the old days this was about all that was needed or expected, but condi-
Fig. 28. An exposed boulder beach, with scant water vegetation. Oneida Lake, New York.

Fig. 29. A sandy bay, Oneida Lake. Note the dark colored windrows of mayflies cast upon the beach,
Fig. 30. A lake formed by damming a brook; the large floating island is a mat of the loosened bottom turf. Kanahwauke Lake, Palisades Interstate Park.

Fig. 31. The brook that feeds Kanahwauke Lake. View taken below the dam.
tions have now changed greatly, and no one can tell when to expect, even in remote woods, a sawmill or some mine or industrial plant, which drains or throws its refuse into streams and lakes. With the automobile these remote waters are now relatively accessible, and over-fishing is a condition that cannot be ascertained by an inspection of the waters. Probably the greatest handicap is that the time available for such considerations is very limited, few have the training to make such determinations, and finally the amount of waters needing examination are so extensive. There are thus many difficulties which usually prevent the proper study of this problem.

Indexes to Fish Habitats. Many efforts have been made to find simple accurate methods of measuring the suitability of waters for fish. Shelford and his students (Shelford and Allee, '12; Shelford, '14, '18a, '23; Wells, '18) have given much attention to this important subject, particularly to the chemical conditions, and the influence of the chemicals on fish. As Shelford ('14) points out, the common methods are three in number: 1, inspection of the bottom, largely to determine the presence of organic débris; 2, chemical tests, largely for decomposition products; and 3, the presence of index organisms known to indicate certain conditions.

Shelford ('14, pp. 29-30) states that: "If a body of fresh water is to support the most desirable fishes it should have an area of clean sand, gravel or other terrigenous bottom covered by from six inches to two feet of water and an area of emerging and submerged vegetation to supply food. It is probable that for the best results these three areas should be about equal... Since most bodies of water contain sufficient vegetation to supply insects and other food for more fishes than can exist there, the amount of terrigenous bottom up to one-third of that occupied by vegetation may be regarded as an index of the suitability of the body of water for food fishes.

The second index is essential but must accord with the first. The chemical character of the water must be such that the fishes will not suffer from it or leave on account of it. Carbon dioxide results from the decomposition of organic matter. In the process oxygen is consumed so that the presence of any quantity of carbon dioxide nearly always indicates lack of oxygen. Fishes are very sensitive to carbon dioxide, turning back from increase of one or two cubic centimeters per liter of the gas in solution. ... Thus the amount of carbon dioxide may be taken as an index of the suitability of the water." (Cf. G. M. Smith, '23, p. 135.)

Wells ('18, p. 568) has further shown by experiment that: "The more resistant species are found in ponds, shallow, muddy-bottomed lakes, or in the stagnant pools of streams. These are the fishes which one sees in aquaria. They are able to withstand increased temperature and wide fluctuation in the oxygen and carbon dioxide content of the water, and to some extent are able to live in the presence of the excretory products of their own metabolism. The
stream fishes proper can not do this, and therefore die when placed for any length of time in standing water.”

“In general, the resistance of fishes is correlated with the environment in which they are found. The more resistant species are found in ponds and shallow lakes while the least resistant fishes occur in the swift streams and in cold, deep lakes.”

Very recently Shelford ('23) has again discussed rather fully the influence of hydrogen ion concentration upon fishes and other aquatic animals, and points out that the chemical methods for their determination are not yet perfect to such a degree as to determine the relative value of this factor. The perfection of the various chemical methods to a point of devising relatively simple field methods will be of great value in fish culture, as well as for other purposes.

Methods of using index organisms or communities of organisms, that is, different kinds of plants and animals whose characteristic presence in water indicate its chemical and other conditions, seem destined to become of considerable importance in determining fish habitats, because of their ready application to field conditions.

Temperature. The usual fish cultural test of suitability of waters for receiving young fish has been the temperature of the water. As concerns certain species of fishes the range of temperature in which each species will thrive, or the extremes of which it can endure, has been approximately determined. But temperature alone is not the all-controlling factor. There are other essential factors to which, in some cases at least, temperature is secondary, as, for instance, when a fish “seeks” a water condition which is colder than that which it leaves, although the temperature in the latter place may be well within its particular “temperature range.” In such instances some other factor, as oxygen, may be the controlling factor, for it is known that lowered temperature signifies greater absorption of oxygen, at least under certain attendant conditions, as for instance in the rapid water of a stream of clear or pure water.

Space will not permit of any extended discussion of bio-physicochemical conditions which are intimately bound up with temperature conditions, and in this connection it is hardly necessary, for after all, temperature is often a fairly good guide. Yet in an investigation all of the factors must be considered in order to learn the significance of many phenomena connected with fishes, the causes of which are obscure.

There are at least two artificial conditions which modify biological capacity, but the extent and the effect of which are not always clearly known. One is that of pollution and the other physical obstructions.

Pollution. Pollution has been accused of all sorts of harmful effects upon fish, and in many instances justly so. But in the words of Evermann ('94), “we know that vast quantities of sawdust and vast amounts of refuse from paper-mills and other factories are let into our streams, and we know, perhaps, that great mortality
Fig. 32. High water conditions in a large stream in spring. Chittenango Creek, New York.

Fig. 33. An example of a stream remaining full through the summer season.
Fig. 34. Red House Creek, Allegany State Park, in summer. An example of a stream which fluctuates greatly in volume.

Fig. 35. Glenwood Brook, Erie County, N. Y., in summer. Note the evidence of much greater volume at certain seasons.
has occurred with the fishes in some of those streams; but do we know that one is the cause of the other? We think that sawdust injured the fish, but do we know it?"

Doubtless the foregoing questions were asked to emphasize the necessity for scientific investigation to prove or disprove prevalent views concerning the subjects before trying to regulate them,—not that Evermann himself probably doubted that certain kinds of pollution at least were injurious to fishes. There can be no doubt of that, for it is known. At first, however, it was inferred. The direct effect of certain chemicals upon organic substances was well known. It was therefore supposed that these chemicals would be injurious to organic life in a stream. There could be no doubt that in concentrated form they would be. How much dilution would render them harmless to fish life, or whether the water in the stream would sufficiently dilute them was not known, and although many investigations both in laboratory and in the field have been made, the questions have not been settled to the extent that the results can be applied to every instance of pollution. Inferences are at times apparently justifiable. For instance, when a stream once frequented by fish is now deserted, and no other modification than excessive pollution has taken place, it is not a wild guess to attribute the fact to pollution. Such a case is the Passaic River in New Jersey. When streams were frequented by fish up to the time mines were opened on the banks, and as soon as mine waste was discharged into the rivers the streams were forsaken by fish, it would appear reasonable to attribute the disappearance to mine waste. On the other hand, when cases of polluted streams frequented by fish are cited, what answer can be given?

It is necessary to ascertain the extent of the pollution and its effects upon other organic life rather than directly upon the fish themselves, for the deleterious effects may be upon the food supply or some other essential condition. It is necessary to ascertain whether the stream is actually frequented by fish more than temporarily. Certain fish may at some time or other ascend a stream which is more or less polluted. They may not encounter sufficient pollution to seriously affect them, or to turn them back, until a long way upstream. The spawning places may be so polluted that the fish cannot propagate. Their migration, in such instances, has been in vain so far as the perpetuation of the race is concerned. Or even if the fish spawn in polluted areas, the eggs may not develop and no young fish be produced.

W. C. Adams, of Massachusetts, says ('21, p. 29): "Observations were made on the conditions in the Merrimac River, not for the purpose of isolating and analyzing the different types of pollution, but rather to determine whether any fish would frequent these waters in their present state of defilement, and to observe something of the fish life in the river. As stated elsewhere, the belief has been general that the condition of this river was such that no migratory fish would frequent it. This has proven to be erroneous by the presence of alewives in the fishway at Lawrence during the past
spring." In another place in the same report he says (p. 84), "The
results from the Lawrence fishway are particularly interesting, inasmuch
as some of the foremost fish experts in the United States have
held the opinion that the pollution of the Merrimac River would
prohibit the use of a fishway by anadromous fish, and that fresh-
water species would make little use of such a structure. We now
know that alewives have passed through the fishway in spite of the
pollution, and that the fishway has been used by various species of
fresh-water fish."

The table of records of fish which were observed in the fishway
including anadromous fish above it, from May 25 to July 6, com-
prised 72 alewives, 19 suckers, 105 shiners and dace, 44 eels, 3
tROUT, 1 sturgeon, and 1 carp.

This proves nothing beyond the fact of the possible efficacy of the
fishway. Nothing is stated concerning the extent of the pollution
at this time in the particular place under observation. Furthermore,
even if large numbers of alewives had passed up, there is nothing
to indicate that they would have found suitable spawning places, or
if they had that the young would have endured the pollution.
SHELFORD ('18) very well indicates, that to all toxic substances the
younger or smaller fish, down to the smallest fry, are more sensitive
than older ones, and that in one instance under observation the resis-
tance of the egg falls gradually from the time of fertilization to the
time of hatching. The point is that "tests of the minimum quantity
of poison which will prove fatal must be made on the most sensitive
stage; the strength of the chain is the strength of its weakest link."

Again, while the pollution may have been comparatively slight or
even absent at the time, there is no evidence that at a corresponding
season another year, the pollution would not have prohibited the
ascent of alewives.

As concerns sawdust, to which EVERMANN referred, while the
immense deposits of the lower St. Croix River in Maine and New
Brunswick apparently did not prevent the ascent of salmon, it is
positively known that they could not breed upon sawdust-covered
spawning beds.

A stream may be polluted in one part and not in another. This
being found to be so in any instance, and having ascertained to what
kind of fish the unpolluted portion is in every way suited, it may be
stocked, provided measures are taken that it shall not be subse-
quently polluted. The advice here offered is not to attempt to stock
polluted waters. If waste can be diverted elsewhere and the water
purified, see that it is done before attempting to stock. It will be
economy, with gratifying results.

In addition to pollution to which reference has been made there
are conditions which may be called natural pollution. Besides those
with which almost everyone is more or less familiar, if he has given
any attention to aquatic conditions, such as the generation of nox-
ious gases, etc., from decaying vegetable matter, there is one condi-
tion in particular that should be mentioned. It is concerned with
acidity of the water. It has been found that bog-water—particularly
that of sphagnum bogs, floods after a prolonged dry period, and the last snow freshets of spring are often more or less deleterious to fish. In an instance of heavy flood following a drought, it was found (Richmond, '21) that brown trout were considerably affected, the young fish being most seriously so. This flood water was found to be nearly four times as acid as the normal water which ran during the drought, and was of an acidity intense enough to coagulate the mucus on the bodies of some of the younger fish.

This is only one of the many natural factors which may affect the habitableness of certain waters by fish, but it is one which may be augmented perhaps by deforestation, with attendant droughts and freshets, and may have some significance in selecting "head-waters" for planting trout, even though the water is apparently cold enough.

An important practical study of New York stream pollution has been made by Suter and Moore ('22). In this they have shown, by a series of plates, representative plants and animals from clean water to a severe degree of pollution. They have also compiled a table showing the limits of toleration of fish to various concentrations of pollution. For a general account of the pollution of New York streams see Ward ('19).

Forbes and Richardson ('13, '19), and Richardson ('21a) have made very valuable investigations of "index animals" in their studies of the pollution of the Illinois River, and very recently F. C. Baker ('22) has given special study to mollusks as indicators of pollution. Because of the sedentary habits of these animals they are of special value as an index. These pollution studies have thus given a new interest to the associations of animals found living together in their minor habitats.

Physical Obstructions. The earliest and most decided artificial modifications of area and capacity of lakes and streams were produced by dams. There are but few if any water systems in the United States, however remote, that have not been more or less affected by dams erected for one purpose or another.

By the erection of many recent dams constantly higher stages of water than formerly have been produced, accompanied by some advantageous conditions, perhaps, such as that of enlarged physical or biological capacity. But even in instances where constantly higher levels are maintained there are usually fluctuations due to utilization of the water. There are other instances where the higher level is only temporary and where it may be reduced to below the original or normal level, so that areas above the dam may become practically dry at times. The fluctuating level caused by drawing off the water tends to destroy the marginal vegetation and the fish food organisms living in this shallow water. (Cf. Moore, '23; Osburn, '21.)

The effects of dams may be not only restrictive upon the limit and approximate equilibrium of life, but injurious by more or less obscure interference with the habits of fishes. High stages of water may afford new feeding areas for some kinds of fish, but this signifies
only change of locality. Fish are enabled to ascend farther up some brooks and even onto overflowed areas, but since in many instances, the stored waters are sooner or later drawn upon, the possible effects are manifestly serious. A sudden drawing off of the water may not only let out many fish which have congregated above dams, but also seriously affect those which have entered the overflowed tracts and small brooks, often leaving them stranded or to slowly perish as the pools left by the receding water become heated or evaporated. High water of a lake may facilitate the ascent of tributary streams by some species in the breeding season, but it also covers former shoals with excess of water, so that other places of suitable character must be sought, and these may not exist.

If, by chance, fish have become accustomed to temporarily prevailing conditions, sudden changes can only be to their general disadvantage and must necessarily react unfavorably upon the perpetuation of the fish supply.

Dams also interfere with the dispersal of fish as well as with their migrations, by obstructing the passage from one body of water to another or from one section of a stream to another. As has been stated, some species make seasonal movements from one place to another for breeding, feeding, or to meet changing seasonal conditions. These obstructions usually are to movements in one direction only. They often permit a downstream movement but not a return (figures 36, 37). So fish which inhabit a lake or the lower sections of a stream must be very seriously affected. In some cases this may be an advantage, by preventing the invasion of upper waters by undesirable fish.

Depletion of many waters and inability to restock them with certain species may be attributable to dams. In some localities attempts have been made to remedy such conditions by affording a passage past or through the dams by means of a structure commonly known as a "fishway."

Fishways. The construction of fishways for anadromous fishes was one of the earliest measures directed toward conservation adopted by state governments. Laws were enacted requiring the owners of dams to provide fishways and in many instances the fishways were constructed and maintained for awhile to become neglected in later years, and seldom have new ones been made. The law concerning the structures was seldom enforced. One reason for the neglect was that the fishways appeared to do no good. The fish did not ascend them.

Thirty years ago an article appeared in a sportsman's journal (Waters, '91) in which, among other things, it was stated that there was an expensive fishway at Holyoke, Mass., built some years previously at a cost of $30,000 and so far as known no shad, salmon, or black bass ever got to the top of the stairs. Nothing but eels ascended it. The facts are that many fishways have been faulty in their structure or location. Furthermore, the same type of fishway will not answer for all kinds of fish, and fishways are expensive and difficult to make effective.
When it is proposed to install a fishway in a dam, both an engineer and one who is conversant with the habits of the fish for which the fishway is intended, should be consulted.

For the purpose of restricting fish to certain localities gratings or so-called screens have been in vogue. These structures merit some discussion as sometimes notwithstanding the presence of a screen, stocking has been a failure or the depletion of waters was not checked.

Screen. It would seem that when fish had unobstructed passage to and fro in any waters naturally inhabited by them, a check to natural movements would be undesirable. But some prevention to their passage over a dam or obstruction preventing return would seem desirable. Observations upon the habits of various fishes indicate that they differ according to the kind of fish and the character of the locality in the propensity to go down an outlet of a lake or to migrate from one portion of a stream to another. Some of the reasons for these movements are plainly evident, others may be inferred, and still others cannot be more than conjectured.

Some anadromous fishes, such as the Atlantic salmon, shad, alewives, etc., descend streams both as adults and young in order to go to sea. In some localities only the outlet affords suitable spawning places for certain kinds of fishes. There may be other seasonal movements of some kinds, perhaps for food. Some fish may gain an outlet by accident, in an overflow or flood, others by some unnatural circumstance, such as the sudden opening of the gates of a dam, or by following a log drive, which they have been said to do for the sake of insects dropping from the logs.

If a body of water is overstocked or the water is uncongenial to the fish, a natural exodus may perhaps ensue in search of food or congenial conditions. There may also be irregular, more or less individual to and fro movements of some kinds of fish, for which no definite reason can be assigned. The fact is, so little is known concerning the habits of any species that it is mere conjecture to attempt to explain the movements.

So far as the desirability of screens is concerned, though, the fact that such movements take place usually is regarded as sufficient. The only question is that of the necessity for a screen and its effectiveness when there is one.

The utility and desirability of a screen depends also upon the kind of fish it is desired to prevent going into the outlet, and the conditions obtaining in the body of water for which the screen is proposed, and the character of the outlet as well.

Usually a screen is installed because of a demand from those who fish in a lake, where the results of fishing appear to be incommensurate with the numbers of fish which have been planted in it, and the first thought is that the fish have departed by way of the outlet. Now, screens are expensive, and when one is demanded, the actual necessity for it and whether or not it is likely to be effective should be positively ascertained by investigation. The cause of any ap-
parent depletion, whether by outlet or some other way should first be learned by competent investigation before going to the expense. In one instance known to the writer, a practicable fishway would be more effective in maintaining the stock than a screen. In another a screen erected at the stated cost of $30,000 is absolutely ineffective in maintaining the stock, and unnecessary too, for the nature of the fish concerned is not to leave the lake in considerable numbers except for spawning. In this case if the fish did go into the outlet in numbers sufficient to deplete the lake an effective screen would be justifiable, as the fish having gone into the outlet cannot get back. But that this lake continued to be well stocked before there was even a dam in the outlet indicates that a screen is unnecessary. Furthermore, this particular screen, as is the case with most screens, while it might prevent the egress of grown fish would not prevent the passage of young fish should they attempt to descend.

Another instance is that of a natural landlocked salmon water. In former years the outlet was a famous and favorite fly-fishing resort; and but few fished in the lake. Also the outlet was the principal breeding place for the fish, in fact practically the only one of considerable consequence. The final erection of a new dam with an impracticable fishway, prevented the return of any salmon which succeeded in gaining the outlet. The natural spawning grounds were also cut off. However, the latter was considered of minor importance as for many years the descent of breeding fish had been obstructed by nets and the fish taken for artificial propagation. The apparent decline of salmon in the lake caused a demand for a screen, which has been installed. It prevents the descent of adult fish, excepting perhaps during log drives, but not of the young fish. It is not known that the young go down, but there is evidence that the screen has not produced the desired results.

The fact is that no investigation concerning the alleged decrease of fish, in any of the waters mentioned, has ever been made. If the cost of the screen in any instance had been devoted to investigation, practical results might have been achieved.

Stocking and Restocking Problems. A body of water is usually stocked for one or the other or both, of two purposes, namely, for food supply or to afford sport.

No small body of water can afford an unlimited supply of food fish. If a market fishery is carried on in inland waters for sport fish, it is impossible for the stock to be naturally maintained. In many, if not all instances, even considered from the sport-fish side, the stock cannot prove self-sustaining save by rigid restrictions and regulations from the beginning to the end; so rigid indeed that it becomes almost, if not quite impossible to afford satisfactory fishing to an increasing number of anglers, and after all, recourse must be had to outside sources of supply.

It might be possible to so manage large bodies of water that they would afford both commercial and sport fishing, but as a rule each class of fishing must be restricted to different species. As
Fig. 36. Sluice dam on Dead Cambridge River, a fine trout stream near Rangeley Lakes, Maine. An obstruction preventing trout from passing upstream.
Fig. 37. Back water on Dead Cambridge River above sluice dam. Trout may pass downstream when the sluice is open, but cannot get back.
previously indicated, all the interrelations of these different species should be taken into consideration when regulations of the fisheries are formulated.

Successful stocking of waters with game fish depends largely upon the kind of fish best suited to the waters, or rather to what kinds of fish the waters are best suited. In other words it is necessary to determine what kind or kinds of fish will likely produce the best results in quantity and quality as game fish.

Individual anglers have their favorite or preferred game fishes; but it does not follow that the water which they or their associates of kindred taste wish to stock will yield the desired results if the particular favorite is planted. The desired results from planting any kind of game fish are fish of satisfactory size, in sufficient numbers to afford good fishing for all who fish that particular water.

As stated elsewhere, all waters are limited in their capacity to support fish. Other things being equal, a large body of water will support more fish than a small one. A large body of water, too, is capable of supporting more kinds of game fish than a small body of water, which fact is due to the usual diversity of conditions or variety of habitats in a large body of water. Any body of water will support a number of kinds of fish in a quantity directly in proportion to the capacity of the suitable conditions for each kind.

In his address to the American Fisheries Society in 1893, President Herschel Whitaker said: “Much has been done in the past few years in attempts to successfully introduce into our waters foreign species of fish, and while these efforts should not be too hastily criticised, it may be said that outside of one or two varieties thus introduced, this work has not been successful. The experiments have been of but little practical value when we count results. It must appeal to the average judgment, after all, it would seem, that if an equal amount of effort, time and means had been devoted to the increase of the native fish which we have that are deserving of care and attention and multiplication, the money, time and effort would have been more practically spent. These indigenous fish are natural to our waters, are of excellent character; it is no experiment to determine whether they will live and thrive. They do not require to be adapted to strange conditions and new surroundings. Is it not better practical fish culture to increase the good varieties that we have than to go far into the field of experimentation? It would seem that the office and function of a fish commission is best fulfilled when it gives attention to the increase of those fish natural to our waters, rather than attempt to solve unsolvable or difficult questions which have but little practical value.”

The principle conveyed by the foregoing quotation is good. It is the one which should have been followed from the beginning, but which has not been strictly followed even since the address was delivered. The consequence has been that in many instances both the native and introduced fish have failed to afford the desired results. This has been discussed in the foregoing pages. There are also instances where introduced fish have supplanted the original
fish. Sometimes this supplantation has been because the conditions were best suited to the introduced fish and the native fish would never have amounted to much in that particular water. Sometimes the ascendency of the introduced fish is attributable to the direct effect of the voracity of that form, and the decrease or disappearance of the native fish is chargeable to the same factor, that is, the first has eaten the other. More often the effect of the voracity of the introduced form is an indirect one, that is, it becomes a competitor for the food supply in which its voracity and activity gives it an advantage. Occasionally the supplanting has been with a fish superior to the native fish, but more often one which in its new environment becomes inferior in one or more ways. There are instances of waters, originally containing no game fish whatever, which by the same haphazard "experimentation" have proved eminently suited to one or another fish. More often the experiments have sooner or later resulted in failure. Some of the failures may be attributed to unsuitable waters, to improper planting methods, or perhaps to too small numbers planted to offset inevitable natural loss.

It has occasionally happened that acclimatization has been effected, not in the immediate waters where the fish were planted, but in some other portion of the water system. In such cases it is unnecessary to say, the fact is attributable to more suitable waters in the one than in the other place. Such successes as these are due largely to chance selection of suitable water and often repeated introductions.

It is natural to believe that waters which have been depleted of the indigenous species could best be stocked by the same species that originally inhabited them. If the fresh waters of the entire State had to be restocked with fish, the logical species would appear to be those of general distribution in the State, but it does not necessarily follow that the original inhabitants of a given body of water are best suited to it, or rather that others will not thrive there as well as the original inhabitants, or even better.

Usually there are more or less restricted localities which are ideally adapted to fish that do not occur there, and are less or even ill-suited to the fish of general distribution in that body of water. For instance, because fish which are common in the lower course of a stream occur to some extent in its upper course, it does not signify that some other kind would not thrive or even do better than the originals in the latter locality. Or the reverse may be the case.

By various means the original conditions of some waters may have been so modified that they are no longer suitable for the species originally occurring there, but still may be suitable for some other species. Mr. Whitaker was right on general principles, but circumstances alter cases. Where a body of water, lake or stream is depleted but still inhabited by indigenous fish which are all that could be desired or expected in food and game qualities, the cause of depletion should be ascertained, and if changed conditions are not the cause of depletion the natural stock should be restored. In the other instances mentioned the logical thing to do is to ascertain to what kinds of fish the waters are best suited and act accordingly.
Problems of stocking and restocking of waters must be considered from at least two and probably three different angles: (1) Is it the intention to make the body of water entirely self-supporting and the fish self-sustaining? (2) Is it intended to make annual plantings, and depend upon them alone for the fishing? (3) Is it expected that the products of natural propagation shall be reinforced by annual plantings of fish?

There are certain requisite conditions for each of these propositions. In the first there must be a permanent and adequate food supply for all ages of fish from the time they begin to feed until they cease to do so. There must be spawning places of adequate area and suitability. These are the principal points for consideration. All others hinge on them, for in a body of water otherwise of eminent suitability, but lacking in either one of these essentials, the stock cannot become self-sustaining.

In the second proposition, in a body of water, if otherwise suitable in every way, spawning places are not a necessary consideration, and the stock may be maintained by regular plantings every year with enough fish to take the place of those removed, or dying from natural causes. But this is an uncertain and expensive procedure.

An extreme example of this sort of procedure — extreme in that a food supply had to be introduced also — is one related by "Billy" Keil (1922) concerning "Salmon Fishing in Sterling Lake." Sterling Lake is a small body of water, according to Mr. Keil about 1½ miles long and a mile wide, situated on the E. H. Harriman estate. It is stated that it carries an average depth of more than 75 feet with a maximum of 126 feet. It has no tributaries and the general character is rocky with the exception of a sand beach at the northern end. Mr. Keil regards it as a spring-fed lake, in fact, virtually itself a spring. It is related that in 1887 Alpine saibling from Europe were introduced and subsequently a few were caught and some were observed for a few years in the lake, then they disappeared. In the late seventies it seems that lake trout had been introduced and apparently "thrive"d for a time and produced fair angling. To the lake trout Mr. Keil attributes the disappearance of the saibling. Finally the lake trout disappeared, due to "lack of food, with its resulting cannibalism." In 1903 Mr. Keil restocked the lake with 30,000 fingerling lake trout and he states that for about ten years following this plant excellent angling for these fish was to be had by the few individuals fortunate enough to obtain a permit to fish this water. "It was not unusual," he says, "for an angler to take four or five trout, averaging 7 or 8 pounds each, in a day's fishing, though from the size of the fish taken it was plainly evident that if natural reproduction was taking place (as no doubt it was) none of the resulting progeny were escaping the voracious maws of the mature fish. From 1913 to 1918 not over a dozen in all of these fish were taken, most of them old specimens and none in very good physical condition."

In 1918 Mr. Keil was engaged by the Midvale Company, who had leased the property, to make a thorough examination of this
lake, and to report upon the possibility of building up and maintaining good angling. He says: "A careful limnological investigation showed that with the exception of food and spawning grounds [italics the present writer's], every other condition (both physical and biological) was well suited to either the ouananiche or the steelhead trout or both. The lack of spawning grounds, of course, could not be remedied, as both of these varieties require good sized running streams for reproduction; but as long as we would have to depend on annual restocking to keep up a good supply for fishing, this was of little consequence. It was found that an ample food supply could easily be built up by the introduction of suitable food fishes, for the water was swarming with the microscopic crustaceans upon which these small food varieties subsist."

Mr. Keil goes on to say that in the spring of 1919 smelt fry to the number of 3,000,000 were planted, and on the 29th and 30th of the following October 2,102 steelheads and 1,264 landlocked salmon yearlings, averaging about 8 inches in length were planted. Again in 1920, 3,072 steelhead and salmon yearlings from 6 to 9 inches in length were turned out. In the spring of 1921 there were planted 3,000,000 smelt fry, and in the fall approximately 3,000 more steelhead and salmon yearlings. Mr. Keil reports that in the summer following the introduction of the trout and salmon, many of these fish were taken, weighing as heavy as 2 pounds. "With the opening of the season of 1921 wonderful reports began reaching us of the big fish that were being taken."

In the middle of June Mr. Keil landed four landlocked salmon running from 2½ to 4 pounds. Later in the summer he secured a steelhead trout which weighed 4½ pounds.

All of these fish, according to Mr. Keil, were gorged with smelt, and "their rapid growth and splendid condition is an illustration of what can be accomplished by the proper building up of a suitable food supply before desired game varieties are introduced."

From what Mr. Keil says it is quite evident that the fish that were caught, whether lake trout, saibling, steelhead trout or landlocked salmon, were simply grown-up individuals from the original plants. Furthermore, it is more than probable that the food supply will need to be annually replenished also, for there appear to be no suitable spawning places for the smelt.

Such procedure is not reconstruction or conservation, but simply fish farming, akin to raising pheasants on a private estate to be shot by the owner and his friends in the fall. This may be all right as a private venture by those who can afford it, but where public money in concerned it would amount to extravagant waste.

The stocking of certain waters with non-indigenous species has already met with an unforeseen serious result. This result was possible of prediction, in fact it was predicted by the present writer in connection with one lake and one species of fish several years before it became manifest. The danger of such a result was not recognized by those engaged in fish cultural distribution. In the case of other species in other waters such fish cultural procedure
has already culminated in so serious a condition that unless radical corrective measures are soon adopted the question will surely arise as to whether in these instances, at least, fish culture has not proved a curse rather than a benefit. For it certainly signifies the not very remote extinction of the species concerned, and in time cannot but involve all species continuously subjected to similar fish cultural operations.

In a foregoing paragraph pertaining to indiscriminate distribution of fishes, reference was made to unsatisfactory results from the distribution and stocking with chinook and landlocked salmon. A few years ago, to meet the objections of those who favored the continuous planting of landlocked salmon rather than chinook salmon in eastern fresh waters, the advocates of the latter fish claimed that landlocked salmon eggs were not available in sufficient quantities, whereas the chinook eggs could be obtained in large quantities.

Why couldn't landlocked salmon eggs be obtained in sufficient quantities, since they had previously been plentiful enough to send broadcast all over the country and to foreign countries for stocking purposes? There can be but one answer, the failure of the source of supply. It has already been noted that in 1919 chinook salmon hatching and planting was abandoned because of inability to get their eggs in sufficient quantities. The reason is evident, namely, the decline at the source of supply in the Pacific Coast rivers.

This is a case where the combined natural and fish cultural production is out of proportion with the take by the fisheries, so retrenchment in egg distribution becomes necessary in an effort to make up the deficiency caused by the fisheries.

The original sources of supply of landlocked salmon eggs were limited in extent and the stock of fish was consequently also limited. But compared with the fisheries the fish were relatively abundant, and provided a supply of eggs and young fish which were widely distributed, as previously stated, but at the same time a certain proportion of the products of fish cultural propagation were returned to the waters from which they were obtained. This proportion was regarded as sufficient to maintain the stock, the view being based upon the unproved opinion that it was in excess of the number which would have reached the age at which the fish were planted, had they been hatched under natural conditions.

Notwithstanding the "liberal" return to the native waters, there has been a continuous though fluctuating decline for some years, and as previously indicated, curtailment of egg shipments became necessary a number of years ago, and at the present time it seems that very few if any landlocked salmon eggs are permitted to go out of Maine. Yet the indiscriminate distribution is said to be continued within that State, notwithstanding the fact that the original sources of supply appear to be failing and the great majority of other waters stocked are evident failures. Outside of Maine there are practically no landlocked salmon waters left of those so intensively stocked in past years, and absolutely none remains with a self-sustaining stock.
For a number of years there has been complaint by anglers that salmon fishing in one of the most famous original landlocked salmon lakes was going bad, notwithstanding the operations of the State hatchery. A notice appeared in one of the papers to the effect that it was proposed to plant "Canadian Sea Salmon" there, apparently to offset the decline of the native salmon. This announcement elicited remonstrance from several persons interested in that lake. An article of this kind having attracted the attention of the Commissioner of a neighboring state, who had also thought of importing the Canadian fish to remedy the unsatisfactory conditions in the water of his state, wrote the author: "At the present time, it is, so far as I am able to learn, impossible for us to get any great amount of real landlocked salmon. A few years ago attention was turned largely to planting western chinook salmon in our waters. They are certainly sea-going fish, as much as Eastern or Canadian river salmon, with the added drawback that their life is short and their reproduction is limited.

"There is no need for me to elaborate on their habits, which you know better than I, but I am discouraged in trying to create a permanent fishery by raising them. We are endeavoring to get all the eggs possible from the salmon taken from our lakes, that is the Eastern variety, but for the past few years we have at no time secured over 70,000 eggs, which is a very small amount compared with what we would like to have.

"I find that it is now possible to obtain the Eastern Canadian River Salmon from the Canadian Government, and it certainly seems to me that our chances of success with these fish are as great, if not greater than with any other species available. Is it not probable that while a percentage of these fish when planted will find their way back to the sea, as large a percentage of them may be expected to remain in the waters? Would not our chances of success with them be greater than with the Western Salmon and while I personally should very much prefer to raise real native landlocked salmon, does not the fact that they are not now available in any adequate numbers make it advisable for us to try the Canadian fish?"

The situation in that State and elsewhere is as follows:

In the first place no effort was ever made to ascertain whether the quota of young salmon annually returned to native waters was in excess of those which would result from natural reproduction. No attempt was made to ascertain the cause of the decline.

Stocked waters elsewhere failed because nowhere was a self-sustaining stock produced. Had the life history of the landlocked salmon been thoroughly learned and the lesson heeded the present situation might have been obviated.

Much money and energy had been expended in trying to acclimate the salmon in other waters. The hatcheries on original waters failed to maintain the natural stock in those waters, and the same obtained in the case of most other waters. Those which have not already failed are failing. Still, in some localities it was
thought that the problem of salmon fishing was solved by the introduction of chinook salmon. This venture failed. Then it was proposed to take a chance with Canadian sea salmon.

How inconsistent such measures seem, when it is seen that years of fish cultural operations on original waters failed to maintain the stock! If fish culture could not accomplish that with an indigenous species under conditions naturally favorable to the fish, how could it be expected from the introduction of non-indigenous forms the habitats and natural habits of which are so different from the landlocked salmon?

If a self-sustaining stock had been produced, as it might have been, in certain places, and had the matter received proper scientific attention, there would now be no stocking problem. As the situation now appears to be, the source of the egg supply bids fair to be exhausted and there is no effort made to prevent it. So in all cases where adequate breeding and food conditions do not exist, temporary successful introduction is marked for failure as concerns some of our most esteemed game fishes.

The egg supply of the chinook has practically failed; the supply of landlocked salmon eggs is nearing complete failure; steelhead eggs will ultimately fail at the source unless preventive measures are early put in force. The same may be said of the Canadian sea salmon. The “rainbow trout” is in almost immediate danger. This form will be discussed more in detail later. Even now much of State and Federal brook trout culture is largely dependent upon private trout breeders for the egg supply.

There is but one preventive remedy, but it is a comprehensive one. The first step is to cease to rob Peter in order to pay Paul, and another is to make scientific investigations, taking into consideration every factor concerned.

The third proposition, however, may apply to waters having limited spawning places, but otherwise capable of supporting more fish than the natural breeding would supply. In such instances, annual plants of young fish may be made to help maintain the stock to a satisfactory point of production, that is, satisfactory fishing, if properly regulated. Such situations are probably the most common today.

Some rather commonly observed facts in connection with waters which previously have been naturally or artificially stocked are those of deterioration in size and decrease in number. Such observations may be classified somewhat as follows:

1. Decrease both in size and number.
2. Decrease in size but not in number.
3. Decrease in size and increase in number
4. Decrease in number but no decrease in size.
5. Decrease in number and increase in size of those remaining.

When one or another of these phenomena has been observed, very often the opinion of scientific authorities has been sought. Not infrequently, however, the cases have been diagnosed by the
observer, without any consideration of past or present conditions other than those immediately observed, i.e., the decrease in size or in number of the fish. Usually, even when the deterioration in size and decrease in numbers are concerned, the explanation of the one fact is in no way related to that of the other. Deterioration in size has often been attributed to "inbreeding," whatever is meant by that term in connection with such cases. The remedy usually recommended has been "new blood." In such explanations, presumably "inbreeding" signifies that the fish have become physically and physiologically "run down" from breeding in comparatively limited numbers. But it does not appear to be recognized that fish have naturally existed for years in some waters and bred together in even smaller numbers without deterioration and that in some other localities fish have actually increased in size as the number declined.

In "Modern Fish Culture," Mather ('00) says that with fowls and the cattle on the farm there is danger of inbreeding because the parents, especially the sires, are so few. But he adds, "There was no such danger among the herds of buffalo and there is none among the trout in confinement. Take the eggs from 2,000 fish and fertilize them with the milt of 1,000 males; turn the progeny loose and breed from them two years later, and what are the chances of mating brother and sister?"

The migration view seldom is supported by any evidence, nor is any reason suggested as to why after residing in a lake for a number of years, the fish should finally decide to change their abode. Such an explanation is particularly illogical when applied to the decrease of indigenous fish which have existed in a lake for untold years. The commonly accepted view that indigenous fish permanently vacate a lake or stream, has led to the unnecessary and therefore wasteful expense in the erection of screens in an effort to prevent the migration.

Undoubtedly when possible, fish will leave unfavorable for more favorable conditions. This fact simply emphasizes the necessity of ascertaining the conditions before introductions are made.

That the decrease in numbers of fish may be attributed to their having been devoured or destroyed by one or another natural enemy, when such enemies are present in the same body of water, is an explanation which it is claimed, is based upon known facts. But in many cases in question the facts have not been verified.

It is known, for example, that pickerel subsist largely upon fish and that they have always been adjudged as notoriously ravenous. When a body of water once containing both trout and pickerel has become depleted of trout the pickerel is accused of being the direct cause of the depletion. Very often the depletion of trout may be more justly attributed to the greed of man than to the voracity of pickerel. Voracity is characteristic of all predatory fishes, and in the case of fish-eating fish "voracity" is a relative term, much depending upon the size of the fish and its opportunity to display that characteristic.
The deterioration and the decrease in numbers of fish will be discussed as follows:

1. Concurrent decrease in size and number of fish may be due to one or more of several assignable causes.

In many instances the apparent decrease in size may be attributable to over-fishing, especially in a comparatively small body of water. To attain a large size the fish require time in which to grow, and persistent intensive fishing tends to lower the size standard by continuously removing the larger sizes, so that sizes previously regarded as small come to be the maximum size attained.

If a size and quantity limit is strictly observed in the fishing (which is seldom the case) the coincident decline of size and number may be due to decrease of food supply, and cannibalism.

There may be other factors than those mentioned which are operating independently. Whatever the cause may be, it can be positively determined only by competent investigation.

2. Decrease in size with no decrease in number may be attributable to one or the other of two common causes. One is that of reduced food supply. The other is that of the larger fish having been caught before they have had time to attain a large size. But the most common cause is likely to be found to be that there are too many individuals compared with the amount of food for them. In other words there is lack of balance.

3. Decrease in size with increase in number may be attributable to inadequate food supply and exceptionally favorable breeding conditions, with freedom from enemies, or it may be a case of over-stocking.

4. A decrease in number with no decrease in size, suggests as a cause over-fishing and unfavorable breeding conditions.

5. A decrease in number with increase in size suggests over-fishing or other destructive agency, with no diminution of food supply, so that the remaining fish are well fed. Or, if the water has been artificially stocked, that the existing fish are merely survivors of the original plants, and that they have not reproduced, at least not extensively enough to maintain the stock.

It has often been noticed that following the first introduction of some kind of fish in a body of water their growth is rapid and they attain a large size in good numbers. Later it becomes evident that the fish have quite generally fallen off in size, or newly planted fish do not grow as rapidly or attain the size of those first planted.

Such instances have been many, and have led the fish commissioners, the fish culturists, or the interested public, to attribute the facts to various causes other than the real one. Or, it may be that while the cause was obscure, or without any consideration of the possible or probable cause, the situation being unsatisfactory, there is a demand for some other fish. If the Commissioner did not comply with the demand, the new fish were sooner or later secured by first getting a new Commissioner. In a few instances the new fish appeared to be the solution, for it waxed great in size and was suffici-
ently numerous to be pointed to with pride in the Commissioner’s reports. However, subsequent reports ignored the fish, or gave it only passing mention, for the reason that it was merely a repetition of the condition exhibited by the first mentioned fish, with the added fact, perhaps, that some other inhabitant of the waters was exterminated.

The size attained by any species depends largely upon the quantity and quality of its food supply, and having sufficient time in which to grow. In the same length of time, other things being equal, some species attain a larger size than other species do. In other words they grow faster. The number of fish that can be produced and maintained hangs on the favorableness of the waters in every way, the number planted, and the number removed. When a body of water is stocked to its maximum limit, only a comparatively few will attain a large size.

It is self evident that a limited body of water cannot afford an unlimited fish supply for an unlimited number of anglers, which judging from some operations, seems to have been thought possible. Every body of water is probably capable of being made to support more life than it did in a state of nature, but any attempt to make it do so is attended with danger. It must be intelligent action, based upon exact knowledge.

In an article by R. L. Barney and H. L. Canfield ('22), a statement is made which applies to natural waters as well as to farm fish-ponds: “The tendency in stocking new ponds or in restocking old ones seems to be toward overstocking. Evidence discussed here-with suggests that, for a pond to gain production of edible-sized fish and still contain a regular large annual production, it must not be overstocked.” And, again, a note in “Fisheries Service Bulletin” (U. S. Bureau of Fisheries, March 1, 1923, No. 94), referring to production of the Fairport Farm Pond, says: “It has been observed that too great a production of young fish in a given year prevents many of the half grown fish from attaining edible size through too serious competition for the available food.”

Overstocking may be effected in two ways: (1) by introduction of too many kinds of fish, and (2) by planting too many fish of any kind.

Before stocking a body of water, it is necessary to ascertain the actual conditions, both favorable and unfavorable, and to determine, to use a life insurance term, “the expectation.” We may judge, if a stream or lake has supported certain kinds of fish, that, the conditions being unchanged, it is again capable of doing so. However, careful consideration is required to make sure that the conditions have not changed and to reach a positive or exact decision respecting the number of individuals the water will support, or, if the conditions have greatly changed, to ascertain to how many and to what kinds of fishes the waters are adapted. In this connection, it should be stated that because certain fishes appear to be of no utility as food or game fish, or because they are predacious fishes commonly designated as fish enemies, and of little value for food or game
qualities, it does not signify that they are useless in the waters inhabited. This is a matter that should also be determined.

Natural Enemies of Fish. The so-called natural enemies of fish are many and various, almost all zoological as well as some botanical classes being more or less represented. Bacterial, fungal, plasmodial and parasitic diseases destroy them individually and epidemically. Non-parasitic, as well as parasitic worms and crustaceans and some insects are not infrequently fatal. Among the vertebrates certain fishes, batrachians, reptiles, birds and mammals can be mentioned. Of these the predacious fishes are generally regarded as the most serious.

The normal enemies of any fish, under normal conditions, have tended to exist in normal numbers until civilization interfered with natural conditions. These so-called enemies are nature's balance wheels and it is only when normal conditions are disturbed that those enemies of any fish become generally harmful to it. Man has been the most destructive enemy of fish in general. He has tampered with nature's machinery and thrown it out of balance. The results have not always been correctly attributed to him, but rather laid at the door of some of the alleged natural enemies.

Man's interference may have increased the number of some enemies and diminished the number of others. Some one natural enemy of a given fish may prey upon other fishes as objects of his "enmity." Some of the latter may also be enemies of the first mentioned fish; sometimes direct enemies, that is, preying directly upon the fish, or competitors for the food supply, or both. In the latter case their injurious effects would be doubled. So if man should destroy the first mentioned enemy which serves as a check to the undue increase of the others, the effect of an over-production of the latter might be worse than before.

There are many well-known instances of lakes and streams, which have been stocked and restocked, but which have shown only brief periods of satisfactory fishing, or none at all. In such instances the most common remedy suggested for the condition has been the extermination of one or another fish alleged to be an enemy of a more highly esteemed fish. Whenever this has been accomplished the desired or expected results have seldom been attained.

Let us take a specific example. In the report upon the investigation of Lake George, elsewhere cited, Mr. Titcomb said: "within the past twenty years at least thirteen distinct species of fish have been planted in the waters of Lake George, and some of them in very large numbers. There has been more special legislation for the protection of the fishes of this lake than for any other body of water within the State. Notwithstanding these facts, anglers report that fishing conditions are not as good as they were some years ago, and this appears to be especially true with reference to the lake trout which may be regarded as the most important food fish inhabiting the lake."
Dr. Needham suggests that "four native species, namely lake trout, small-mouth blackbass, yellow perch, and bullheads, are the ones to be fostered and encouraged as being perfectly adapted to the conditions of the lake; and these should be rigidly protected during their respective spawning seasons. While the northern pike is highly prized by some, it is not worthy of propagation or protection because of its voracious fish-eating habits." (Italics the present writer's.) Recommendation 4 is: "that the law for the protection of great northern pike or 'pickerel' be repealed."

Dr. Needham says that undoubtedly the most extensive and exclusive fish eater in the lake is the northern pike or "pickerel" but that no studies of pike food were possible at Lake George because the stomachs of all but one that were examined were empty. He stated, however, that the records of examinations extending over many years at Cayuga Lake showed them to be almost exclusively fish eaters. In another place he says: "the pike should probably hardly be considered an enemy of the lake trout, and perhaps not even a serious competitor, for it keeps to surface haunts and hardly invades the grounds of the trout in deep water. But it certainly is both an enemy and a competitor of the shore fishes; doubtless it eats mainly herbivorous shore fishes like shiners, that are most easily captured; but it doubtless eats the game fishes as well when it can catch them."

Superficially considered, a fish sometimes appears to be "his own worst enemy" in that it is addicted to cannibalism. In some instances it is very probable that fish eat their own kind because they are driven to it by starvation. But there are several known instances of fish devouring the eggs of the same species on the spawning beds. Trout, salmon, whitefish and others have been observed to do this habitually in some localities. In the cases of trout and salmon it is stated that it is usually the young fish which lurk around the spawning beds looking for fresh eggs. But in the case of whitefish the present writer once found gravid as well as spent female whitefish with their stomachs distended with whitefish eggs (Evermann, '05, p. 103-104).

There is a great need for careful study of the food habits of fish eating birds. Two authors who have discussed this subject are Warren ('97) and Tavener ('15), the latter describing the salmon eating habits of the double-crested cormorant. The kingfisher, although frequently condemned, has never been carefully studied.

The parasites of Oneida Lake fishes have received preliminary study by the N. Y. State College of Forestry cooperating with the U. S. Bureau of Fisheries (Pratt, '19, '19a, '23; Van Cleave, '23). The problem of these parasitic diseases deserves much more attention than it has received in the past.

**Fish Planting In Public Waters.** Mr. W. C. Adams of the Massachusetts Commission says it is a common experience to find that in spite of the good intentions of the receivers, many consignments of young fish, which have cost money and great labor to rear, are entirely wasted through improper planting.
Long before this a former State Fish Culturist of New York wrote (Bean, '16) that as a rule the special care given by the State Commission ceases when the cans of young fish are delivered to applicants on the platforms of the railroad stations. "In many cases," he said, "the lack of special knowledge and experience on the part of those who transport the cans to the streams and do the actual planting results in great loss. Thus certain waters that have been stocked with thousands upon thousands of fry and fingerlings during a long period of years still produce, for one reason or another, very indifferent, if any fishing."

Failure for so many years cannot be attributed alone to those who have received and planted the fish. The responsibility for this to quite a degree rests upon a system which acts blindly, trusting to chance in such matters. We have seen that these defects are largely operative even today.

The principal fault was lack of knowledge concerning the conditions obtaining in the waters in which the fish were planted, whether the waters were suitable for the fish, and other facts which should have been taken into consideration. While many young fish are lost through improper handling and planting the most potent cause of unsuccessful stocking is the lack of favorable conditions for the fish. Such conditions differ in relation to the size or the age at which young fish are planted.

Fry or Fingerlings. Opinions differ concerning the age at which young fish should be planted. Some fish culturists advocate fry, others, fingerlings, and still others, older fish. Each exponent supports his view with valid evidence. Bean ('16), in favor of fry planting, said that all the different states and the United States distribute fry, and their experience has demonstrated beyond question that fry planting can be made effective; that prejudice against fry can usually be traced to improper planting methods, or unsuitable streams, and that it should not be forgotten that nature herself plants fry exclusively. Some claim that more fish will grow to maturity from several thousand fry than from a few hundred fingerlings, as in hatchery produced fish the instinct of self-preservation is developed better and sooner in fish planted at the earlier age. Another argument advanced in favor of fry planting is that of the attendant difficulties and expense of raising and handling older fish, and that fry can be transported and distributed in a greater number than is possible with fingerlings or older fish. However, in favor of older fish than fry, it is quite generally admitted that the older a fish is the better able it is to take care of itself. Concerning these points it should be borne in mind that "circumstances alter cases."

The report of the Conservation Commission of the State of New York for 1919, concerning trout, says: "Although there is a great difference of opinion as to whether the best results are obtained by planting 5,000 sac absorbed fry or, for instance, 250 four-inch fingerlings, experienced fish culturists are inclined to favor the
planting of 5,000 fry, providing it is possible to distribute the fry in the headwaters of spring rivulets tributary to the stream which it is desired to stock. Spring rivulets may be found tributary to nearly all good trout streams. They may vary in length from one or two miles to a few feet. In width they may vary from six inches to two feet, and in depth from one to six inches. The number of fry to be planted in such rivulets depends very materially upon the length of the stream, and the prevailing abundance of food. Few persons have opportunities to study the food conditions, and it is accordingly safe to generalize by the allotment of 5,000 fry to each mile of spring rivulet, with the understanding that special care will be taken to scatter the fry the entire length of the rivulet by planting a few at frequent intervals with a dipper.

"There is an important argument in favor of planting fry, namely, the instinct of self-preservation, which is developed better and sooner at the time of sac absorption, when the fry instinctively seek natural food. The planting of fingerlings late in autumn, when the water is very cold, is to be discouraged, for the reason that after being trained to receive artificial food several times daily for a period of several months, if planted in these cold waters, which are almost devoid of food, fish which have been accustomed to seek food under natural conditions become weakened from starvation and are an easy prey to any fish of larger growth inhabiting the same waters.

"Small fingerlings properly planted the latter part of May or during the month of June, reach the waters it is planned to stock at a period of the year when there is far greater abundance of minute animal life. The natural food upon which they feed then exists in greater abundance than later in the season when the larger fingerlings are planted. The results obtained from planting twice the number of two-inch fingerlings than can be furnished of four-inch fingerlings two or three months later will accordingly be in favor of the two-inch fish."

Some fish culturists also regard it as more economical to plant fry than to raise the fish to a larger size. This may be true so far as the immediate pecuniary considerations are concerned. But if an undue proportion of the fry perish after planting, the apparent saving in immediate outlay of money is a delusion, for the operation in an effort to perpetuate the stock by planting large numbers in any waters, in the long run is costing far more than is saved by the actual lessened expense of planting at the fry stage.

"The chief argument against planting of fry that has been offered is that they are less able to withstand unfavorable conditions than are fingerlings, and many applicants for fish have not been trained to give the planting the attention which it requires. The Commission is accordingly devoting much attention to systematic educational work among the applicants with a view to better planting, and meanwhile is continuing its efforts to increase the output of fingerlings." (Loc. cit.)
From the foregoing it is seen that the policy of the Commission as well as views of individuals vary from time to time. It is the failure of nature to maintain the supply of fish demanded today, which has given rise to the question of how best to meet the demand, and the difference of opinion concerning at what age the young fish can best be planted. The character of the habitats or places where the different stages of young fish live, as well as of adults, varies with the species of fish as do their habits in relation to the conditions under which they live. Nature selected the habitats and they are naturally the best possible places and conditions, else the species would not have survived.

The life histories and natural habitats of some kinds of fish are so well known that it is comparatively easy to decide at what age, when, where and how they should be planted. But there are others concerning which little or nothing is known in the direction mentioned. In the latter case it is obvious that results will always be uncertain until the unknown facts are learned. As remarked elsewhere it is a waste of time, money and good fish to plant any kinds before they have attained an age concerning the needs of which there is definite knowledge.

Aside from the question of economy in raising and transporting young fish, the character of the locality to be stocked and what is known concerning the life history of the fish to be planted become determining factors in deciding the best age at which to plant the fish. Other things being equal, the food and feeding habits of young fish are of first importance. In a general way the natural food of adults of the common species is known, but upon what some of the same fish subsist in the earliest periods of their lives is not definitely known. Although this is so, as concerns waters naturally inhabited by a given species, or waters in which it has become permanently established, the food for all ages of that species must be present in the habitats of the fish at the respective ages, or else the fish would not occur or have been established there. Therefore, if the habitat of fry is known and the habitats of the older young fish are unknown the logical age to plant the fish is as fry, other things being favorable. So with the older fish.

In the case of fry, if it is necessary to plant fry and the natural spawning places of the species are known, it is a justifiable assumption that, other things being equal, the best places for planting them will be on those spawning places, for there is where nature plants fry. If it is known that fingerlings naturally occur in certain shallow water localities, or in deep water, or at the surface at a distance from the shore, those would appear to be the natural places in which to plant the fingerlings. Again the same may be said of older fish.

The object of planting the fish is to supplement the native supply or make up for a deficiency in natural production. In this connection it should be borne in mind that from the time, at whatever age, the fish is planted, nature takes her course, and the only advantage attainable lies in the greater number reaching maturity than would
result from the natural process. So by planting fry on the natural spawning places, or older fish in their natural habitats, the only gain attainable lies in the greater number planted than would have hatched naturally from the same number of eggs deposited by the parent fish in the spawning places, or in the case of older fish would have resulted naturally from that number of naturally produced fry.

As elsewhere suggested, the question here arises, are the spawning places capable of supporting more fry than would hatch naturally? They are, of course, other things being equal, if the natural supply of parent fish has been reduced. In this case the question concerning the extent of reduction arises; also the number of fry to supply the deficiency. The same reasoning may be applied to fingerlings, yearlings, etc., in their respective habitats. To exceed those numbers in the final production of adult fish, might result in disturbances of natural conditions that would give rise to worse conditions than those which the artificial planting is intended to correct.

When to Plant. The season of the year when young fish should best be planted has been a much discussed subject, and there has been more or less diversity of practice. The season would seem to depend to some extent upon the kind of fish. However, the natural habitat of the fish at the age to be planted being known, it would appear to be a logical procedure to plant the fish approximately at the time they are known to appear naturally in those places. However, the differences in time of hatching and rate of growth of hatchery-raised fish may be a matter to be considered in this connection.

While, as has been stated, there are many facts and factors to be considered in selecting the places in which young fish are to be planted, there is one of prime importance, and that is the food supply for the young fish.

Food Supply. In the words of a former United States Commissioner of Fish and Fisheries (H. M. Smith, '16), "our knowledge of the food of fishes is as yet seriously inadequate. The food taken by fishes varies with the species, with size and age of the fish, with the season of the year, and with the abundance of the various kinds of food material present in different bodies of water. A few observations in one locality or at one season of the year afford no criterion for the conclusions that we may seek to draw, for an appraisal of the possibilities of fish production in a body of water, for an understanding of the variations in the sizes attained by a given species of fish in different bodies of water, and for the direction of our efforts to promote an abundant and reasonably constant supply of food under all conditions subject to control."

Other things being equal, the statement is likewise true that "barring enemies and artificial hindrances to increase, such as over-fishing, fish will multiply up to the limit of the food supply, but cannot overstep that limit. If the food supply can be increased, an increase in the number of fish will naturally follow." (Pieters, '01, p. 59.)
These facts have been long recognized by those who have given the matter of fish culture any intelligent thought. But it is remarkable how little attention has been given to the food of fishes. In a general way the food of the adults of the commoner species is fairly well known, but very little is definitely known concerning the food of the young of many even common forms. Over forty years ago, a "pioneer fish culturist," Seth Green, said that one of the principal precautions to be regarded in stocking streams was not to put in too many fish, and that the food supply of the fish must be considered. Again, one year later, he stated that the secret of successful stocking of waters with fish was in putting the right kinds in waters suited to them. These facts are now as emphatically true as they were so many years ago, although they have always been more or less disregarded. It is not such a simple thing as it might seem to determine to what species of fish a given body of water is best suited, but in a general way, certain conditions being known, it may be inferred that the water will or will not support certain kinds of fishes. However, in fish cultural practices of the past, such inferences have been based largely upon conditions pertaining to adult fish, and little or no attention was given to the matter of food supply of young fish after they left the hatcheries, and even today too little consideration is given that point in stocking and restocking natural waters. For years there has been much discussion concerning places in which to plant, the season in which fish should be planted, and the food of young fish in the hatcheries.

It seems to have been assumed that the young fish could find its natural food abundant anywhere at one or another season of the year, but until comparatively recently no investigation was made to ascertain what constituted the natural food for various ages of the different species, or whether suitable natural food at any time was sufficiently abundant to supply the number of fish planted. The number planted often depended upon the amount of stock on hand and the "pull" of the applicant.

It has been generally assumed that youngest stages of most carnivorous fishes subsist upon the minute organisms, such as water fleas, etc. This assumption is based upon observation of a few species only. It is now known that the food of some species consists of such minute life. A few scientists have made a specialty of the qualitative and quantitative study of the lakes and ponds of various localities.

Although much data pertaining to these subjects have been accumulated and published, usually in technical form, with few exceptions they have been correlated with the habits of young fishes only in a very general way. This fact is due to the lack of trained investigators able to devote themselves to such work. Those who have contributed to the knowledge in this direction have usually been college professors and students who have done so with little or no pecuniary remuneration.

*Plantings.* The foregoing pertains to planting fish in waters
where the fish occur naturally or have become established from previous introduction. In planting fish in waters not previously inhabited by them, assuming that the waters have been found to have the requisite conditions for grown fish, the first thing to ascertain is the presence of adequate food supply for the young fish. In this case as in the natural waters unless the nature of the food and other requisites of the young of a given species are known, it is better to refrain from planting it until the facts are ascertained. It is more economical and more promising of positive results to investigate first, then plant, than to plant first and then investigate. In other words, plant according to present knowledge; or acquire knowledge, then plant.

PROPAGATION AND DISTRIBUTION OF FISH BY NEW YORK STATE

In 1916 the New York Conservation Commission issued a guide for stocking the inland waters of New York State with food and game fish, entitled "Fish Planting in Public Waters," of which Dr. Bean was the author. Under the heading: "General Principles of Stocking," this pamphlet contains a very valuable discussion concerning what may be termed the technique of fish planting. The principal topics are: "Stream Study and Plans: Essential Preliminaries"; "Planting Points and Food Supply"; "Fry Versus Fingerlings"; "Care During Transportation"; "Importance of Water Temperature"; "Planting"; "Artificial Stream Pools and Side Pools"; "Receiving and Rearing Stations."

Under the heading "Directions for Planting Various Species," the principal fresh-water fishes listed are: "Brook Trout"; "Rainbow Trout"; "Brown Trout"; "Lake Trout"; "Landlocked Salmon"; "Common Whitefish"; "Round Whitefish or Frostfish"; "Lake Erie Herring"; "Ontario or Greenback Herring"; "Tullibee"; "Pike Perch"; "Yellow Perch"; "Small-mouth Black Bass"; "Calico Bass"; "Muskellunge"; "Smelt" or "Ice-fish." Concerning each of these species the discussion is very brief although the statement concerning the character of places in which to plant is specific. This information concerning some of the species is not based upon actual knowledge and the recommendations are the result of inference rather than investigation. While very much lacking in positive information, the instructions are the best possible to be derived from available existing knowledge. The present writer must confess to inability to add much to what Dr. Bean has said, which only goes to show the need of attaining to a degree of knowledge by study of those subjects to render fish planting a rational procedure.

In the following paragraphs concerning fish planting no original instructions are attempted. Brief extracts are made from Dr. Bean's directions concerning each species, and an occasional modification or comment is made.

Since this pamphlet was published Dr. Bean's list of species of fish
distributed has had other species added to it and some subtracted from it, according to the Eleventh Annual Report of the Conservation Commission for the year 1921. Also during other years species not mentioned in either list were distributed to some extent. Reference will be made to some of these.

The Trouts and Salmons. The trouts and salmons comprise the most highly esteemed and ardently sought for game fishes in the eastern states, and of the game fishes they have also received the greatest amount of fish cultural attention. A number of other species than those mentioned in this connection have been introduced and distributed in waters of the eastern United States, but with no real success. Only those at present propagated and distributed by the State of New York are discussed in the following pages.

Brook Trout. Bean (16) states: "The best places for planting brook trout are in the rivulets and spring feeders, tributary to the larger streams, into which the fish will work their way as they grow. Make sure that the brooks are not such as will dry up or become stagnant during the summer. . . . The fry are ready for distribution in March or April and fingerlings from May to July. The latter should not be planted in quite such small streamlets as the fry."

"The streams to be stocked should not rise above 68 degrees in temperature during the summer. Brook trout will not live and thrive in warmer waters. It has been found in various parts of the State that certain streams formerly abounding in brook trout will no longer support this species, and in many cases it is quite evident that this is directly due to the cutting off of the forests and the consequent increase in temperature of the waters through exposure to the sun. The banks of the stream should be grown with trees or tall shrubs in order to provide the necessary shade and coolness. Where the vegetation has been removed, black alder or quick growing willows may be advantageously planted along the banks. It is useless to place trout in waters made impure with sewage, mill, dairy or other refuse, for they are peculiarly sensitive to pollution and will not remain in such waters."

For many years the upper temperature limit of 68 degrees has been observed. But Embody (21) adduces evidence from experiments tending to show that this standard for the upper safety limit has been set too low. Other conditions being wholly favorable. Referring to his experiments with young brook trout and other species in small artificial ponds and "wood races" in 1920 and 1921, Embody emphasizes the point that brook trout will withstand a degree of temperature considerably higher than the usually accepted upper limit. In one instance, "The brook trout passed through a temperature of 83.3 degrees F. without loss, but with evident distress and failure of appetite. They apparently recovered on a drop of nine degrees over night and a maximum of 79.7 degrees the following day. They lived through five succeeding days with the maximal temperatures ranging from 78.8 degrees to 80.7 degrees
F., but began to die at 84.2 degrees (mortality 20 per cent). None died the following day, July 4, at 82.4 degrees; but on July 5 at a temperature of 83.2 degrees F., the mortality was 100 per cent.”

Concerning the experiments Embody says: “It must be understood that the foregoing rates do not prove that all strains of brook trout will stand a temperature of 80 degrees F., and above. Undoubtedly, there is much variation in this respect just as we find great variation in the rate of growth, in the behavior of trout to current and light, and variation in power of resistance to disease germs.

“Nor may we assume that brook trout will thrive in any pond or stream whose temperatures do not exceed these uppermost limits. Waters vary greatly in oxygen and carbon dioxide content, and these gases may be present in insufficient amounts in one case or too great amounts in the other to permit trout to live even in the low temperatures of the average trout hatchery.

“So far as temperature alone is concerned, however, it is the writer’s opinion that we have been a little too conservative and that we shall have to revise to some extent our notions as to the meaning of the terms, warm water and cold water.”

In the discussion of Embody’s paper at the meeting of the American Fisheries Society, the comments which were more or less adverse to the higher temperature limit, largely pertained to hatchery experiences. But Mr. G. C. Leach, head of the Division of Fish Culture of the Federal Bureau of Fisheries, suggested that the volume of water is one of the determining factors as concerns the temperature-withstanding ability of trout.

Again Embody (’22, pp. 7–8) says that the views which he quotes concerning the temperature safety limits, were made prior to 1880, when the trout brooks possibly were colder than they are today, and continues: “There is a possibility that through natural selection our speckled brook trout is gradually adapting itself to warmer waters. According to present day evidence either this must be true or certain statements of Ainsworth and Green were not based upon complete observation. For upon an examination of the temperature data from certain trout brooks in this county, we find a number of instances where speckled trout apparently thrive and take the hook in waters whose highest temperature ranges from 74 degrees to 79 degrees F. The highest temperature in which speckled trout were found was 81 degrees F. This was in the upper Van Pelt Brook where three specimens were clearly observed apparently not inconvenienced by the high temperature.

“In other parts of this stream, brook trout were observed in temperatures of 76°, 78° and 79° F. In the Dusenbury stream they were seen in temperatures of 79° and 80° F.

“It must be kept in mind that the temperatures referred to were taken on the hottest days of the summer of 1918 when the maximum air temperature in the open ranged from 95° to 100° F. Thus they probably represent the extreme conditions occurring in these streams. In order to find out the fluctuations in water temperatures, a series of readings were taken in a warm, unshaded part of the
Dusenbury stream where brook trout occur, with the following results:

"Fluctuations in water temperature in Dusenbury Brook between 2 p.m., August 6, and 3 p.m., August 7, 1918:

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Air Temp.</th>
<th>Water Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 6</td>
<td>2:00 p.m.</td>
<td>94</td>
<td>80</td>
</tr>
<tr>
<td>August 7</td>
<td>7:00 a.m.</td>
<td>79</td>
<td>67</td>
</tr>
<tr>
<td>August 7</td>
<td>10:00 a.m.</td>
<td>80</td>
<td>68</td>
</tr>
<tr>
<td>August 7</td>
<td>12:30 p.m.</td>
<td>85</td>
<td>70.5</td>
</tr>
<tr>
<td>August 7</td>
<td>1:30 p.m.</td>
<td>91</td>
<td>76.5</td>
</tr>
<tr>
<td>August 7</td>
<td>3:00 p.m.</td>
<td>94</td>
<td>80</td>
</tr>
</tbody>
</table>

"The extremes of water temperatures as read are 67° and 80°, a daily range of 13°. It is doubtful that the water temperature went lower because the minimum air temperature recorded by the local weather bureau was only 79°. From these readings it is evident that the high-water temperatures are not of long duration [italics the present writer's], probably not longer than five hours. It is, therefore, clear that some speckled trout experience no ill effect from temperatures of 79° and 80° when only of short duration. While it may be true that a temperature above 70° F. would be unsafe in a crowded hatchery pond, the writer feels that for wild, rapid, unpolluted streams the unsafe temperature is higher; how much so he is not prepared to say. The temperatures of 79° and 81° as stated above, however, are very significant even though they may not obtain in many trout streams. Notwithstanding these extreme cases the writer prefers to err on the safe side and therefore recommends as a basis for future stocking with brook trout that 75° F. be taken as the dividing point between 'cold' and 'warm' waters.'

Embody also refers to "other factors" than temperature to be considered, saying that trout may thrive in one brook where the temperature is 80° but not in another. This point has been discussed in preceding pages, but perhaps it may be well to suggest that the same may possibly obtain with trout and 75° F.

The present writer is inclined to regard it unwise to accept the old views and conclusions as irrefutable unless they have been established as scientific facts. He also recognizes that the term, "established scientific fact," like "warm" and "cold" may be a relative one. But any claim that the results of a very limited amount of observation in a restricted field upsets all conclusions based upon years of experience and observation in a wide field, should be carefully considered with all the evidence in hand.

Embody's investigations are valuable and his observations in those directions are commendable and should be continued. But, because his observations appear to be at variance with the older ideas concerning temperature, especially when he admits that other factors are doubtless concerned, to attempt to explain the phenomena by attributing them to "adaptation through natural selection," to the present writer would appear to be dangerously near "deep water." At any rate a discussion of that subject in this connection would be out of place. However, it may be that the present writer is so
obtuse as to take Embody's remark literally and as seriously intended when it may have been merely to emphasize the contrast in the results of his temperature observations with the long standing belief that $68^\circ$ F. was the dead line in the upward temperature range for brook trout.

Be that as it may, it would appear to the writer that in planting trout the slogan, "safety first," should be regarded, until it is established that everywhere and under all conditions $75^\circ$ F. is well within the natural temperature range. If it is proved to be so, it will not signify that a new adaptation is taking place but that it is one condition which is comprised in the consummation of thousands of years of adaptations to changing environment and other conditions through a complex of natural forces and "factors" which has been indefinitely referred to as "natural selection."

In the study of conditions of the streams in Allegany State Park in August, 1922, no trout were observed below the wooded region. In Quaker Run the temperature varied from 52 to 67 degrees F., being coldest in the upper waters and progressively rising downstream. The temperatures were taken on different dates from August 1 to August 28, at different times of day from about 10 a.m. to about 4:30 p.m.

From the upper waters to a certain point in the stream the temperature averaged 53.7 degrees and at no time exceeded 55 degrees, and that figure was observed near the place mentioned, simply indicating a transition into the warmer waters below. Below the said point the temperatures ranged from 58 to 67 degrees, averaging about 61.7 degrees, from August 2 to August 28, between 10 a.m. to 3:15 p.m., the higher readings being found lower down and latest in the season. It is interesting to find that in the neighborhood of this point a notable limitation of the fish distribution occurs. Certain species occurring below do not occur above. Others which continue to some distance above these are not found still further up. Others continue still higher, then cease. And, finally, only one form is found associated with the brook trout throughout.

At the precise point referred to is a large pool in which two good-sized brown trout were observed (figures 38, 39). One fingerling brown trout was found a short distance above. While brook trout occurred throughout the wooded section of the stream, they were most abundant above the point mentioned.

A small tributary stream joining Quaker Run some considerable distance above this point showed a temperature of 55 degrees on August 7. It contained a good many small trout for the extent of the stream. On the same day a mere rivulet some distance below this tributary showed a temperature of 62 degrees. It contained some young trout. Below this another rivulet of about the same size showed, on August 11, a temperature of 56 degrees.

One of the most considerable tributaries of Quaker Run joined the stream near the previously mentioned dividing point. The temperature taken on August 11, 12 and 14, in different sections of the brook from 9:30 a.m. to 3:00 p.m. ranged from 54 to 61
Fig. 38. A deep pool in Quaker Run, Allegany State Park. Both brown and brook trout occur here.

Fig. 39. Quaker Run where it enters the pool shown in figure 38. An excellent spawning place for trout.
Fig. 40. A large pool on Quaker Run, at beginning of open stream, probably below summer trout limit.

Fig. 41. Quaker Run near where English Run enters. A good trout brook above this point.
and averaged 56.6 degrees. The weather conditions were clear and warm on the first two days and on the last day clear and very hot. Trout were common in this brook.

Another considerable tributary joins Quaker Run just below the wooded section of the stream, the lower limit of the season’s observations (figures 40, 41). Trout were common in this brook, particularly well up the stream. The temperature ranged from 64 to 67 and averaged 65.5 plus, on August 16 and 18, from 10:30 a.m. to 4:30 p.m. The weather conditions were clear and hot.

In connection with a large, rather open pool in the woods, which contained trout, the following temperature observations were made: Air in the shade 81°, in sun 91°; running water in shade immediately above the pool, 64.5°; in the pool immediately below, 65.5°; running water immediately below the pool in shade, 65.5°. August 17 was a clear, very hot day. On that date a section of brook tributary to Red House Creek was examined. In the upper section of the brook, which was in the rather heavily wooded hills, the temperature of the air in the shade was almost uniformly 75 degrees. The temperature of the brook was uniformly 59 degrees excepting near an inflowing spring where it was 58 degrees.Emerging from the woods into an open country, a small shallow pool was observed which contained one trout 7 or 8 inches in length. The temperature of the air in the shade here was 80 degrees and that of the water 74 degrees. Seventy yards further along in the open country was a pool under a shelving ledge where a number of fair sized trout were glimpsed as they disappeared under the shelf. The temperature of the air here was still 80 degrees in the shade, and that of the water was 75 degrees. Not far below the brook joined Red House Creek, where the air registered 92 degrees and the water in an open pool 85 degrees.

In connection with the 75 degrees set by Embody as a dividing point this is interesting, as it shows a rather sudden transition from “cold” to “warm” water, and that the intermediate section was occupied by trout only at its upper end, although apparently in 75 degrees of water temperature. It was impossible, however, to determine the temperature under the shelf. The open brook below contained multitudes of black-nosed dace, very few of which were found above the open tract. Red House Creek was “alive” with cyprinids of several species, suckers, and small blackbass.

If the limited temperature observations of the Allegany Park trout streams could be regarded as significant of anything concerning brook trout they would indicate that the optimum conditions are in waters not warmer than 60 degrees, and that 75 degrees represents the limit of even temporary endurance. However, the present writer makes no claim that they are sufficient for such a deduction. But given a stream the temperature of which does not exceed 60 degrees in the hot season, other things being favorable, no one need hesitate to plant brook trout in them. If the higher degrees are observed, other conditions such as possible hotter and dryer seasons must be considered also.
Lake Trout. Bean referred to the lake trout as one of the largest and most beautiful of native species of the salmon family, which thrives in cold, deep lakes, and is an omnivorous feeder, subsisting chiefly upon ciscoes or lake herrings and other small fish; but he said nothing concerning the food of young lake trout.

It was stated that the fry were ready for distribution by the Commission in March or April, the fingerlings from May to July, and that they should be planted on rocky shoals or reefs in lakes, very near to deep water.

In the report upon the work at Lake George, Dr. Emmeline Moore, one of the participants, whose special subject was "the primary sources of food of certain food and game, and bait fishes," states (Moore, '22) that the natural food of the very young lake trout still remains a mystery. Nevertheless recommendations are made by other investigators and contributors concerning the planting of young lake trout. Dr. Needham says that it must be remembered that their first food will be water fleas and other minute plankton; that these are taken by mechanically straining the lake water through the gill rakers, and that a large quantity of water must be strained to get the hundred or so of the water fleas required for a single meal.

This appears to be a statement based upon analogy and not upon direct observation. Very likely, if lake trout fry were planted in the places recommended, they would be compelled to feed upon the small organisms mentioned or nothing.

The recommendations to plant the young lake trout in water deeper than 40 feet was not based upon any known food requirements of the young fish, but upon freedom from enemies at that depth. But in the same report Mr. Titcomb well says that it is hardly natural to transfer fingerling trout from the shallow water of the rearing troughs, not over six inches in depth, to water fifty feet in depth, and that it is a matter of conjecture as to whether they are prepared for so sudden a change in water pressure as they will encounter at a depth of fifty feet, where they will actually go after diving out of sight.

It may be added that what they will feed upon if they remain at those depths is also a matter of conjecture.

Nevertheless Titcomb accedes to the recommendation, but adds that if by strictly adhering to the revised methods of fish planting the trout of Lake George do not come back as expected, the only alternative will be to keep them in breeding ponds until they are a year older before planting; and that in the meantime, further efforts should be made to learn something about the life history of the lake trout under natural conditions, from the time it hatches on the spawning beds until it is a year or two old.

Besides the uncertainty of the young fish being able to withstand the unusual pressure at a depth of 50 feet, there may be some doubt whether a fingerling lake trout is capable of straining the minute organisms mentioned as its prospective food in deep water, in sufficient quantity to afford it a meal.
The whitefish or "Lake George Smelt" is a plankton feeder. Its gill rakers number about 55 on the first arch on each side, and are close set, which with the corresponding arrangement on the other arches provide a very fine strainer. The lake trout has less than half that number, and they are not very close set.

Mr. Titcomb further said: "Unfortunately the biological survey did not result in the capture of any immature trout, and the life history of this species up to one or probably two years of age, their feeding habits and their chosen environment remain incompletely known. There is no definite knowledge of the early life history of this species in connection with other lakes. The smallest specimen taken by the angler is said to be eight inches long, or a two-year-old fish. Since they will take the angler's lure, it may be assumed that the 8-inch fish feed upon young whitefish. From fish cultural experience, it is probable that they begin eating small whitefish at a much earlier state."

This last statement is also conjecture. The present writer would suggest that it would be more economical to immediately set about learning the life history of the lake trout, and in the meantime carry out the "alternative," if upon due consideration it seems advisable, rather than plant fingerlings of which the habits are unknown, in water of the depth mentioned.

As a small contribution to the life history of the lake trout, it may be mentioned here, that nearly twenty years ago the present writer found "fingerling" lake trout in a rivulet and a small brook tributary to First Connecticut Lake in Northern New Hampshire (Kendall and Goldsborough, '08). The following are the data:

July 16. In a spring rivulet tributary of the main inlet not far above its mouth, several were caught, two of which, 2.37 and 2.08 inches long, respectively, were saved.

July 18. In the same rivulet another specimen 2.08 inches long was taken.

August 10. In Alder Brook, directly tributary to the lake a mile and a half or more from the first mentioned rivulet four were caught, measuring 2.08, 2.06, 2, and 1.87 inches long, respectively.

The stomachs of the first mentioned specimens contained "black fly" larvae, insect fragments, and an insect egg. The contents of the stomachs of the lot taken on August 10 were black fly larvae, insects' heads and wings, and "mosquitoes."

As concerns the insect larvae and insects, after such a lapse of years, the present writer cannot be sure that the larvae and mosquitoes were correctly identified. However, it is quite positive that both were dipterous insect forms, and it is not especially essential to know the species. It is sufficient to know that these fingerlings were in little brooks and were feeding upon dipterous insects, both larvae and adults.

Whether these fingerlings were some of the recently planted fish or naturally hatched fish is not known. Whichever they were their presence in these little brooks is significant. It is not known where or just when the 25,000 young lake trout were planted, or whether
fry or fingerlings, but it is fairly certain that they were not put into these little streams. The point is that fingerling lake trout were in a rivulet and small brook and were feeding upon insect larvae and insects. In an effort to ascertain the habits of young lake trout in Lake George or elsewhere it may be well to search the small brooks flowing into the lake. It is well known that salmon and brook trout fingerlings, hatched in a larger stream, make their way into smaller tributary brooks and rivulets where they remain until they have attained a considerable size.

A good example of a "deep water" fish having like habits is that of the Burbot (*Lota maculosa*). The present writer found young of this species, 1.9 to 2.45 inches long in spring pools of a small spring brook in a hay meadow on Indian Stream in the Connecticut Lakes region. The brook at this time was not connected with Indian Stream (a tributary of the Connecticut River below First Connecticut Lake), but doubtless had been during higher stages of water. In the same region young of the same species, from 2.75 to 6 inches long were taken in East Inlet of Second Connecticut Lake. The stomachs and intestines of all these young fish contained a variety of food consisting of fragments of insects, larval insects ("black fly"), Entomostraca and mites. Young burbot have been found in brooks of various other localities.

While the burbot affords no direct evidence concerning the lake trout, the above facts are mentioned to indicate that although the lake trout is a "deep water" fish which spawns in the lake, the young are not necessarily deep water inhabitants.

**Rainbow Trout.** Bean says that this is a native of the mountain streams of the Pacific coast, where it occasionally descends to the lower stretches of the rivers and even passes out to sea. He states that its food as well as its habitat is similar to that of the brook trout and that both fishes will live in harmony in the same waters, but that the rainbow seems to show a tendency to work downstream, passing over dams and falls that it cannot ascend again, thus abandoning the headwaters. He goes on to say that it has been introduced with great success into lakes that are landlocked, so that it cannot escape, but that such lakes should have small tributary streams up which the rainbow can run to spawn.

Embody ('22) indicates that rainbow trout will live in waters where the temperature ranges upwards of 85 degrees and suggests that there is good evidence for believing that it will do well in waters the oxygen content of which is a little lower and where pollution is a little greater than is the case with brook trout. He says: "Resistance to high temperature and to certain conditions fatal to brook trout makes it possible for the sportsman to stock many streams with brown and rainbow trout which would otherwise contain only minnows and suckers."

Again referring to the rainbow trout, Embody says: "There is another factor to be considered in the case of that fish and that is the migratory instinct. The practice of introducing rainbows in
many small streams is very likely to result in failure because the stock generally put out in the East is of the migratory variety. These rainbows seem to remain in the stream until they are a year old and in some cases two years old, after which they go down stream to the nearest large body of water whether a lake or a large cold river. The majority of rainbows taken in a small stream outside of the spawning season are from 4 to 8 inches long, although in exceptional cases a few up to one foot long have been captured. But the larger, heavier fish are rarely if ever taken in brooks except during or just after the spawning season in April and May.

“Now if rainbows are planted in small streams which have no immediate connection with a lake or large cold river, they are sure to leave the stream permanently before they are large enough to furnish good sport, but if a large cold lake is available the larger fish will spend most of the year in the lake, returning to the brooks in spring to spawn. Thus it is hardly worth while to plant rainbows in streams which do not flow directly into some lake or cold river or in those where the ascent of trout in spring is blocked by impassable falls.”

There appears to be some inconsistency in what Embody says concerning requisite conditions for rainbow trout. The statement that they will live in waters where the temperature ranges upwards of 85 degrees and possibly in lower oxygen content than the brook trout is not exactly in accord with the statement that it is hardly worth while to plant rainbows in streams which do not flow directly into some lake or cold river. The latter statement, however, agrees with Bean’s remark that the rainbow seems to show a tendency to work downstream. The belief in this tendency is traditional and almost proverbial. For many years the idea that the rainbow would not only stand but requires warmer water than the brook trout has been prevalent, but some fish culturists have taken exception to this generally accepted rule. As long ago as 1886, the first noted success in acclimatization of rainbow trout was announced as having been accomplished in streams of the Ozark Mountains region. An inspection of Spring River, a tributary of the Arkansas, showed that at least three generations of trout were present as the result of a plant of fry in 1880. The largest fish observed weighed between four and five pounds. The second in size measured 15 to 17 inches, while the sources of the stream swarmed with thousands of young from 4 to 5 inches long. Of the streams it was stated that they were “clear and cold, the temperature of the water not rising above 58 degrees in the heat of summer.” (Bull. U. S. Fish Commission, Vol. 6, 1886, pp. 447-448.)

A former Commissioner of Pennsylvania (Meehan, ‘95) wrote: “The rainbow trout early attracted the attention of the government authorities engaged in fish culture, and they felt the desirability of transplanting the species into eastern waters. While this was a laudable sentiment they fell into an error which, being spread broadcast, for several years and even yet to some extent caused and is causing much useless labor in stream planting. Finding the rain-
bow trout were abundant and indigenous in streams of a very warm climate, the government authorities before noted, without giving the matter close attention, arrived at the conclusion that this fish would thrive in waters of a higher temperature than the eastern brook trout, or charr, and so publicly expressed themselves. The result was that as soon as the first lot of fry were ready for distribution, there was a widespread and great demand for them. Many of these fish were placed in streams the water of which was as high as 70 degrees, and in which there was not even the compensation of aeration by extreme rapidity of flow. To the surprise of those who stocked streams of this character and even many waters in which speckled trout lived, there was not a vestige of the fish. Of the hundreds of streams in this state stocked with rainbow trout fry supplied by the government and by the Pennsylvania Commissioners scarcely any planted in the early years of the experiment yielded any returns. At length the secret was discovered.

"In taking the climate of California as a basis for the expression of belief that the rainbow trout would thrive in water of a higher temperature than the eastern brook trout, the authorities made a grave error. While the climate was much warmer, the waters in which the rainbow trout had their original home was of the coldest, purest character, having their sources in the perpetual ice and snow of the mountains. As a matter of fact, instead of thriving in warmer water, the rainbow trout actually demanded colder water for their well-being than the eastern trout. Since this discovery the planting of rainbow trout has met with greater success but the work is still far from being satisfactory."

As previously noted, Bean says that its food as well as its habitat is similar to that of the brook trout and that both fishes will live in harmony in the same waters. In another publication (Bean, '97) he says of the rainbow trout: "Contrary to what has been stated heretofore, they will not endure high temperature as well as brook trout."

On the other hand, in a discussion of a paper read at a meeting of the American Fisheries Society (Seagle, '02), Mr. Titcomb, among other things said: "These rainbows have been introduced in New England and New York State, and in most cases have disappeared after a short time. I have in mind one stream where rainbow trout were introduced by accident. A gentleman had a private pond and reared some rainbow trout and they got into this stream which was a natural trout stream, but the lower end of it warmed up too much in summer for speckled trout. These rainbows held their own in that stream for a number of years, but all the best fishing was at the lower end in warm water, but they did breed there naturally for a time—in fact at one time there were three rainbow trout to one speckled trout—and yet today you perhaps catch in that stream in the course of a season a dozen rainbow trout, but the speckled trout still holds its own. There are lots of places in Vermont where we have introduced rainbow trout and they have entirely disappeared—just the reverse of Mr. Dean's experience in Missouri."
In a discussion of a paper by the present writer read at a meeting of the American Fisheries Society (Kendall, '20), Mr. Titcomb said: "Something like thirty years ago I was talking with United States Commissioner McDonald, and I asked him what results he had obtained with rainbow trout in the East. I remember he stated that they had sent great numbers of them into the waters of New York State, and that they had all disappeared. I have not had much experience personally with New York waters, but it is particularly interesting to me to study the results of planting rainbow or steelhead trout. We do not know absolutely what waters are suitable for rainbow trout. It is a curious thing, but we have streams in New York and a few in Vermont where planting of rainbow trout has been followed with very good results, and where they have reproduced and maintained themselves afterwards. But in the majority of these streams in New York State where the rainbows have been planted, the fish have absolutely disappeared; and yet there are streams which we annually plant with fish and which afford good fishing for the rainbow trout, so-called. It is corroborated by anglers that these are good rainbow trout streams. Now we choose for the rainbow, as we do for the brown trout, the lower waters of the streams where the tendency is for the water to become considerably warmer and is not congenial for the native brook trout. We do not consider the rainbow so destructive to the brook trout as the brown trout. The rainbow trout, if planted in the headwaters, naturally works down into the larger, deeper pools of the lower part of the stream, where the temperature is higher."

No adequate explanation for the vagaries, idiosyncrasies or uncertainties of the rainbow trout as shown by the foregoing quotations, and many other accounts of experiences, has ever been offered.

The paper to which Mr. Titcomb's discussion just quoted pertained was an attempt to indicate the present situation as concerns the rainbow trout of eastern fish culture. It stated that from about 1880 to about 1895 the only rainbow trout propagated and distributed in the East were raised from eggs of trout from the McCloud River, which is one of the headwater tributaries of the Sacramento River. For a number of years the propagation of the rainbow met with varying success according to the conditions obtaining where its propagation was carried on. It was found that they did better at some hatcheries than at others. But finally difficulties and puzzling conditions arose for which the remedy was thought to be the adding of "wild" rainbow trout to the "domesticated" brood stock.

At first these wild trout eggs came from California, but as the records show, not from the McCloud River but from the Klamath River basin where the McCloud trout did not occur. Later, wild rainbow eggs were taken in Nevada and Colorado. In both of these places the rainbow trout were originally introduced, and consisted partly of McCloud trout and partly of Klamath trout. Still later the United States Bureau of Fisheries has been securing its wild trout eggs from fish of the Madison River, Montana. These
were also introduced. Steelhead trout were also introduced into the same stream. The propagation of steelhead trout was undertaken much later than that of the rainbow, and their eggs have always been taken from undoubted steelhead trout from Oregon and Washington. Unfortunately a long discussion of names of the rainbow and steelhead confused the minds of fish culturists and many were misled to believe that the rainbow trout and steelhead were one and the same species, and they accordingly mixed them and propagated and distributed them together as rainbow trout.

However, prior to the United States Fish Commission trout operations in the McCloud River, the State of New York undertook the introduction of western trout into New York waters. Bean ('09a, p. 250) says:

"Importations of California brook trout were received with the intention of placing them in New York waters. On March 31, 1875, 1800 eggs were received, but a number of them were lost in transportation, and on January 7, 1876, there were 260 alive, looking fine and healthy, and about three inches long.

"At Caledonia, according to the Tenth Report, a pond contained trout of this kind which were then about two and one-half years old. They were considerably larger than brook trout of the same age. They are a hardier fish and do well in New York waters. No eggs have yet been given by these fish.

"The Commissioners recognized two kinds of trout in California, the mountain trout and the McCloud River trout.

"In the spring of 1875 the Commissioners received 300 eggs of the mountain trout from Mr. Newell, of San Francisco. Of these 300 hatched; they lived and grew until they were three years old and commenced to spawn, which was in the spring of 1878. They then weighed a pound apiece and only twenty-five of them had died. The remaining 275 gave 64,000 eggs which when hatched were distributed throughout the State, with the exception of 17,000 retained at the hatchery for breeders. In the spring of 1879 there were of the old fish 260 still alive, and they being then older and larger than the year previous produced 94,000 young. These were all distributed but 34,000 of which we lost scarcely any, so that in January, 1880, we have about 250 five years old, 17,000 two years old, and 34,000 one year old. . . ."

"Of the McCloud River trout eggs 5,000 were obtained in 1879 by an exchange for an equal number of our brook trout eggs. They hatched in the spring of that year, and at the time of the Eleventh Report they had by actual count made, while moving them from one pond to another, 4,742, showing a loss of only five per cent in both hatching and raising."

From the foregoing it is seen that even from the beginning the New York Commissioners recognized two kinds of trout, but whether they recognized differences of structure or appearance or just a difference of names is not known. As a matter of fact the "mountain trout" and McCloud River trout were distinct species.
Or it should be said that a McCloud trout which entered into the United States fish cultural operations was a different species from the mountain trout of coastwise streams. More than one kind of trout has been stated to have occurred in the McCloud River; Jordan described and named two species. There is evidence that one of the two was possibly the same as the fish now known as steelhead. So even in the stock derived from the McCloud River there may have been a mixture from the start.

Whatever the composition of brood stocks may have been it is known that in many instances the so-called rainbow trout have been mixed and interbred with steelhead trout. Also that some steelheads have been distributed as rainbow trout. So it is quite clear that there are positively two, and more than likely, three species comprised in the propagation and distribution of rainbow trout in the East. It is more than merely possible that the observed differences in habits of the rainbows and the differences in results in stocking waters with them may be attributable to this fact.

In stocking waters with rainbow trout, then, it is highly essential to know what form is being planted, but even a trained ichthyologist might be "stumped" in trying to identify the young. In localities where successful acclimatization has been effected the matter is simplified if an adequate egg supply is obtainable from the "rainbows" of the locality. As long as the fish is satisfactory to the angler in every way, it won't matter much to him whether it is one species or another and he can continue to call it a rainbow with no harm done. In propagating and distributing that form, the essential thing is to determine fully the habits of the fish, and the exact conditions of the water in which it has proved a success and compare the data with the obtaining conditions in the body of water which it is desired to stock.

As concerns hatchery brood stocks it would appear desirable to ascertain their actual composition, if possible, and select the form, if there are more than one represented, which appears to be the successful one in the waters already satisfactorily stocked.

Where a brood stock is an unadulterated one like that mentioned by Nevin ('20), the problem would appear simpler. He said: "As to rainbow trout, I think we keep a larger stock of breeders and take more eggs than any of the middle or eastern states. We do not have the trouble in raising them that we do with the brook trout in the same waters where we hatch and distribute millions of fry. These fish have been bred from the same stock for the past forty years, and the eggs and fry from our stock of breeders last season were as strong and vigorous as any we had ever taken."

From the foregoing it becomes quite evident that definite instructions concerning stocking with rainbow trout cannot at this time be prescribed. However, Bean ('16) says that since the rainbow spawns somewhat later than the brook trout, the fry are not ready for shipment until May or June, and the fingerlings from July to September.
Brown Trout. Bean stated ('16) that the brown trout is a native of Europe, and that it has become acclimatized in many parts of the United States. He said that it is very hardy and ranks as one of the finest game fishes, and that it lives in clear, cold, rapid streams, its food and habits being similar to the brook and rainbow trouts'. He added, however, that since this fish grows to a much larger size and preys upon the others, it should never be introduced into waters already supplied with native trout. He further stated that it withstands a higher summer temperature than the brook trout, and has replaced that species in certain waters where the surrounding forests have been largely cleared away.

Embody indicates that the brown trout will live in water up to 83 degrees and possibly in "a little lower oxygen content" and "where pollution is a little greater" than in the case of brook trout.

W. C. Adams ('20) says that "in 1917, after four extraordinarily hot days, there were found at the dam at Littleville [Massachusetts], where the water was 84 degrees, 37 dead brown trout weighing from one to five pounds eight ounces, the largest 27½ inches in length. This occurred at a time when the river was unusually low. In normal times the fish would have saved themselves by dropping down to cooler water."

This would suggest that 83 degrees of heat is somewhat too near the danger line to be accepted as a standard of upper temperature limit for the safety of brown trout, and especially if there is lower oxygen content or pollution.

Embody ('22) says: "It is believed that of the three trout the brown trout is the most predacious and most destructive of other fish and it is often stated if a stream is stocked with all three species the browns will eventually exterminate the others. There are many streams where brook trout have disappeared or become greatly reduced in numbers a few years after the introduction of brown trout, but it has in no case been proved that the brown trout has caused the trouble. In fact there are streams in Tompkins County where the brook trout and brown trout occur apparently in equal numbers and have lived so for a number of years."

"Often the upper part of a stream," he says, "is well suited to brook trout while in the lower part browns only will survive. In such cases an impassable dam or falls conveniently located will make it possible to stock the lower part with browns without injuring the brook trout fishing above."

Concerning this fish, Nevin ('20) says: "We intend to increase our capacity and keep a much larger stock of brown trout in the future than we have in the past, as the fry planted in our streams have done exceptionally well. I do not find from observation that the brown trout are any more destructive in the way of cannibalism, of which they are accused, than any other variety of game fish."

The present writer is emphatically opposed to the brown trout in any waters where the brook trout exists or can be made to exist. There are waters which have become unsuitable for brook trout, in which brown trout have become established and afford
satisfactory fishing. His advice is, however, to refrain from planting them in any stream or pond suitable for brook trout, or in waters from which they can gain access to brook trout waters, although it is doubtful if brown trout would thrive in numbers in the colder trout streams. But some might live, and those which do survive become competitors for the food of the brook trout, even if they do not harm the latter directly. Furthermore, there are certain waters which are intermediate between the best environment of brook trout and the best for brown trout. In such places brook trout can be satisfactorily maintained but if brown trout are added the brook trout may succumb. This advice is given with reservations, however, and is subject to revision in the light of further knowledge. The present writer may be sentimentally influenced but he believes that there is no better trout than the brook trout and that we should maintain it whenever possible.

Bean said that the fry of the brown trout are shipped in March or April, the fingerlings from May to July, and are planted as in the case of the brook trout.

**Steelhead Trout.** The steelhead was not included in Bean's (1916) list of fish propagated and distributed, but the list in the Eleventh Annual Report of the State of New York Conservation Commission for the year 1921 included it. A table is also given showing the numbers of fish distributed each year from January 1, 1917 to December 31, 1921.

Of steelhead trout fingerlings there were 28,4,660 in 1917; 74,100 in 1918; 142,900 in 1919; 466 in 1920; and 118,000 in 1921.

Although steelhead trout have been planted as rainbow trout, wherever they have been placed under the name of steelhead, one is fairly sure of the species. At least it is known that the eggs have been derived from Washington and Oregon fish which were ascending the streams from the sea and that the question is not as complicated as is that of the rainbow trout. There have been successful acclimatizations of steelhead trout in eastern waters, the most notable of which is its establishment in Lake Superior. It is known to have become established in some small lakes also, but in them appears seldom to attain a considerable size. However, the steelhead is not regarded as a suitable fish for streams in which a permanent resident is desired and it is advised to plant them in the large lakes only, and then only provided the waters are not already stocked with native salmonids. As a game or food fish, it should be remembered that it spawns in the spring and is likely to be in poor condition during the usual trout fishing season, and that it is in its best condition only in late summer and fall.

As the steelhead spawns in running water the same cautions and rules apply to planting the fish as in the case of others of like habits.

**Landlocked Salmon.** All that Bean said of the landlocked salmon was that only a small number of eggs of this species were obtainable, through the United States Bureau of Fisheries, and all the fry were planted by the Commission in Lake George.
The general situation as concerns this species is discussed elsewhere in this paper (pp. 273-275). In the Lake George report, Titcomb says of this fish: "In response to a public demand, landlocked salmon have been planted annually in the lake: 15,000 or 20,000 and sometimes more have been put in the lake or in the tributary streams for a long period of years. Reports indicate that the results have been unsatisfactory, an average of about ten mature salmon being caught from the lake each year. The salmon are stream spawners, and the fish have usually been planted in the trout streams tributary to the lake. It is their habit to remain in the streams until they are from a year to a year and a half old, or until they are eight or nine inches in length. During this period they have a line of red spots along the lateral line, and many anglers make the mistake of catching them for trout. Some of the streams are fished very hard, and these immature salmon respond to the lure of the fly fisherman more readily than do the native trout. It is probable that a large proportion of the fish which reach six inches in length are killed by the angler before they have an opportunity to reach the lake."

He refers to one stream where to reach the lake they have to run the gauntlet for the last mile in a comparatively small channel of still water inhabited by "northern pike" and other spring-raised fishes to reach the portions of the lake which are congenial to them. It is stated that this stream is the most important tributary of the lake for landlocked salmon and that it is reported that an occasional mature salmon has been seen there in the fall of the year, evidently having returned for the spawning function but never in sufficient numbers to indicate that they have become established in the lake.

Titcomb was of the opinion that improvements would follow if the young salmon were planted in one or two streams and these streams kept closed to all fishing, but regarded it as a still better procedure to rear them up to a length of eight or ten inches, "the size when they naturally leave the streams," and then to plant them in the lake.

Keil ('21) stated that if really good results are to be expected from planting landlocked salmon in deep lakes containing no permanent tributary streams, the fish must be held, regardless of size, until they have passed the parr stage and begin to take on the silvery coloration of the smolt. In a discussion of Keil's paper Mr. Titcomb, among other things said:

"Some of you know the difficulties of getting landlocked salmon introduced into your waters. The State of New York has been planting salmon in its lakes for the past 25 or 30 years, and today there is not a public lake in the state where we have any salmon fishing. Every year from 20,000 to 30,000 are hatched and during the last four years we have put out as high as 100,000 salmon, chiefly in Lake George, with an annual yield of perhaps 10 adult salmon a year to the anglers. The fish were formerly planted in the lake, and later in the tributary streams, where I believe they
should be planted. A good many were caught from the tributary streams when they still had the red spots which they carry until eight or nine inches long. After the investigation we decided it was useless to attempt to stock a lake like that, unless we could carry the fish through the smolt stage. The State today has one lake entirely under its control, posted and screened, where they have been planted for three years to determine the possibility of developing a source of supply for eggs."

Basing the view upon the known habits and habitat conditions of fry and fingerlings it would appear to be a reasonable assumption that the best places to plant such young salmon would be in streams which afford the requisite conditions for the young fish until they attain the size or age when they descend to the lake. This point has been discussed in preceding pages.

What determines the time of migration or descent to a lake has not been ascertained, and it is a subject which should be investigated.

If, however, it is necessary to plant young fish directly in a lake whether there are suitable tributaries for breeding fish or not, they should be reared to the stage suggested by both Titcomb and Keil. It appears very probable that the widespread lack of success with landlocked salmon stocking and the decline of the fish in their original lakes may be due in part if not largely to planting fish, when too young, directly into the lake or into other unsuitable waters. However, as previously remarked, a self-sustaining stock cannot be expected if not aided by natural breeding.

**Fishes Other than Salmonids.** Many other species than trouts and salmons are propagated by the Federal government and certain states. Only a comparatively few of them are generally regarded as game fish, although some may be game fish in one locality and not so considered in another. Some species are propagated mainly in the interest of the commercial fisheries, although one or more of these may be regarded as game fish, at least locally.

As previously noted the fish cultural attention of the New York State Conservation Commission is principally directed to the trouts, but it also propagates or rears other fish for either game fishing or commercial fishing, or in some cases, for both purposes.

The limits of this bulletin prohibit a detailed discussion of all species of "artificially propagated" fishes, even if there was available information concerning them. Therefore, only those at present distributed by the Conservation Commission are included in the following discussions, and most of these not because any additional light can be thrown on them but to call attention to the deplorable dearth of knowledge concerning them, and to indicate the need of investigations which they have never received and which they must receive before success will follow the fish cultural efforts.

**The Blackbasses and Crappies.** Probably next to the trouts the blackbasses are the most ardently pursued game fish. There is probably more detailed knowledge concerning these two species than most other game fish, not excepting the brook trout. For that
reason their culture has in late years been attended with general success. Mistakes have been made in transplanting, but they may be avoided in the future, if the lesson from the mistakes is heeded.

The blackbasses are classified as members of the sunfish family which also includes not only the well-known sunfishes but various other species such as the rockbass, crappie and others.

In New York besides the blackbass the only other member of the family now to any extent propagated appears to be the "calico bass" or black crappie.

1. Small-mouth Blackbass. According to Bean the food of the young consists of crustaceans, insects, and insect larvae. Emmeline Moore ('22) made a very complete record of the food of this species. She says: "Young bass begin their carnivorous existence at once as they rise from the nest. Before the yolk sac is fully absorbed they are actively feeding upon the most minute midge larvae, waterfleas, or other small crustacea. Their taste and capacity for larger prey is rapidly acquired, but they continue to select much of their food for the first few weeks from the same or similar groups of organisms, even under varying conditions of environment."

From her records, she says it appears that the most important single items in the food of the young small-mouth bass are waterfleas.

It is known that fry of this species linger for some time in the vicinity of the place where they are hatched: so the places suitable for spawning nests being known and the presence of food being ascertained, the fry should be planted in such places. But Bean says that the Commission does not distribute bass fry, and that fingerlings are available for distribution in September and may be planted in the shallow parts of the water to be stocked.

In Lake George, Titcomb ('22) states that during the month of August fingerling bass were in evidence about the islands and landings on the lake shore almost everywhere. From what is known of them elsewhere it may be assumed that in most suitable waters they will be found in like situations in September, and that fingerlings may be planted accordingly. In any event there appears never to have been any difficulty in stocking with blackbass.

2. Large-mouth Blackbass. Bean did not include this species in the list of those planted by the New York State Conservation Commission. Except in large bodies of water with a diversity of conditions which would afford adequate habitats for both species of blackbass, it would not appear advisable to plant both in the same water.

Forbes ('80), from an examination of a few specimens, indicates that this species in infancy subsists largely upon Entomostraca. While some Entomostraca were eaten by blackbass an inch to two inches in length nearly half of the food consisted of insect larvae and insects; also some fish were taken. When from two to three inches long the food consisted entirely of insect larvae and insects. The
food of adults was largely composed of several kinds of fishes and some crayfish, 86 per cent of the food being fishes.

Pearse ('15) shows that young blackbass from about two up to a little less than two and a half inches fed upon small larvae, insects, amphipods and Entomostraca; and that from twenty-seven specimens from about two inches up to about four inches, averaging a little over three inches, the diet was composed of 14.2 per cent fish, 31.2 per cent insect larvae, 38.6 per cent insects, 3.8 per cent amphipods, 2.5 per cent Entomostraca, and 1.6 per cent plant fibre.

Moore ('20) says that Chironomid larvae are among the most important single items in the dietary of the young of this species.

3. Black Crappie. Bean says: "This small bass occurs in streams as well as in lakes and ponds, and is a very good game fish. Its average weight is about a pound. Its food consists of worms, small crustaceans, and fishes."

"Fingerlings are available at the same time, and may be planted in the same way, as blackbass."

Concerning this species Pearse ('19) gives the following summary of his observations made in Lakes of Wisconsin in 1916.

"1. This paper attempts to compare the habits of the black crappie with those of the perch, with the purpose of ascertaining why the former is better suited to shallow lakes and the latter to deep lakes.

"2. The food of the crappie consists chiefly of insects, particularly immature stages, entomostracans, amphipods, and fishes.

"3. In spring amphipods and entomostracans are the chief items in the dietary. During the warmer months crappies feed largely on insect larvae, pupae, and adults, and on cladocerans. In winter adult crappies take little or no food in Wisconsin lakes.

"4. Feeding is most active at night, or in early morning and evening.

"5. Young crappies feed for the most part on copepods, cladocerans, insect larvae, and amphipods. During their first season they increase rapidly in size until the temperature of the water falls to about 4 degrees C., but grow very little during the winter.

"6. The rate of digestion in the crappie is about the same as in the perch, but less food is eaten at a time and feeding is more deliberate.

"7. In southern Wisconsin lakes, crappies spawn after the water temperature has reached 19 to 20 degrees C., or more; while the perch spawn earlier, when the temperature is 8 to 9 degrees C.

"8. During the winter crappies remain in deep water and are comparatively inactive. In spring they come inshore and remain in shallow water throughout the summer.

"9. Crappies have few parasites when compared with perch.

"10. Though perch are more abundant than crappies in the shallow lake investigated, they do not attain large sizes. Crappies are large, and, considering their larger sizes, relatively abundant.

"11. Crappies are better suited to shallow lakes than perch,
because: (1) they can better endure high temperatures; (2) their feeding habits enable them to secure food more easily; and (3) they are less subject to infection by parasites."

Yellow Perch. Bean says the yellow perch is found in lakes, ponds and rivers and that it feeds upon small fishes, crustaceans, and other animal matter. "Fry are available in May and June; fingerlings from September to November. Plant in shallow parts of the waters to be stocked." The few specimens examined by Forbes (1880) showed that the young less than an inch long had eaten Entomostraca with a few insect larvae. Perch from about one to two inches fed largely upon Entomostraca but had eaten a considerable quantity of insect larvae and insects. Still larger fish had eaten nothing but insects in the aquatic stages; still other youthful perch up to about four inches in length depended upon aquatic stages of insects and small crustaceans. The most comprehensive account of the perch is that of Pearse ('20), in which the youngest perch examined (from about 1 1/6 to about 2 3/10 inches long) are stated to have fed upon aquatic forms of insects, entomostracans, small amphipods, et cetera.

Records in general indicate that the perch varies its diet according to locality, or rather according to the available food. It would appear that the adult fish is almost omnivorous. It is a fish eater of some voracity and capacity when fish that it can handle are available. The present writer has found perch gorged with young smelts, and has known them to take adult smelts four or five inches long and shiners of like size when used as trolling bait for salmon. They have been observed to take small frogs used as live bait for blackbass.

Pikeperch. Apparently no study of the life history of this important food and game fish has been made. According to Bean the pikeperch prefers lakes and rivers with clear water, and with rock, gravel, sand or hard clay bottom. It feeds upon minnows, crawfish, and insects and their larvae.

The fry are distributed in May, within a few days after hatching. They may be planted on sandy or rocky shoals in lakes and their tributaries. In some waters, at least, the pikeperch ascends streams to spawn in early spring. Since the young are planted so soon after hatching it would appear a logical procedure to plant them in the spawning places.

Muskellunge. Of the pikes only the muskellunge of Chautauqua Lake is propagated by the State Conservation Commission. Bean ('16) says that it should be planted only in that lake and other waters belonging to the Ohio basin, and that young fish may be planted in May and June near the shores of lakes.

There are no records of the food and habits of the young muskellunge.

Smelt; Icefish. Bean wrote: "This marine species ascends rivers to spawn, and has been introduced or landlocked in Lake Champlain
and other lakes of the State. It is in great demand as a table fish, and is useful in furnishing food for landlocked salmon and lake trout."

There is no doubt but that the "icefish" of Lake Champlain is a permanent inhabitant of the lake. It is neither landlocked nor introduced. In Lake Champlain there appear to be two distinct sizes of adult or mature smelts, as there are in a number of lakes in Maine. Whether these two sizes are distinct species or races or merely different age classes has never been determined.

The spawning places of the Champlain smelt or icefish have never been discovered though some effort has been made to find them. But since in other fresh waters there are no known instances of smelt spawning in a lake, and inasmuch as they always spawn in a stream or waters where there is some current approximating a stream, it is believed that the Champlain fish must have similar habits. The spawning of smelts is not restricted to rivers. They will enter the smallest accessible stream for the purpose. Since the smelt or icefish of Lake Champlain is of such commercial importance it would seem highly desirable that the habits of the fish in that lake be studied, and since the smelt is in demand as a food supply for salmon and trout it would appear also of practical importance to ascertain whether the two sizes mentioned are distinct species or races or just age classes. If the first was the case the practical utility of such a determination would be according to the purpose of the stocking. If it were for human food the large size is the one which should be used. If for food for fish, particularly salmon, the small size would be most desirable; for it would always be of suitable size for the fish, whereas the large smelt attains a size which makes it a very formidable, predacious and cannibalistic fish, and one too large for food of the average salmon.

Bean wrote: "The eggs are collected in March by the Long Island station, and may be shipped in the eyed stage a short time thereafter. They should be planted in small, rocky streams tributary to the lake that it is desired to stock. Since the eggs are adhesive, they become attached to stones, sticks, and other objects, where they remain until hatched."

The transplanting of eyed eggs appears to be a better practice than to attempt to transport the tiny, delicate, thread-like fry. It has been found that a good way to handle smelt eggs is to collect them on some material such as moss, brush, or even burlap and transplant them in that shape.

**Bullhead; Hornpout.** The catfish family comprises several highly esteemed food fishes, some of which attain a large size, and some of which are locally regarded as game fish. However, it appears that the only species reared or distributed by the New York State Conservation Commission is the common bullhead or hornpout.

Dr. Bean did not include the bullhead or any of the catfishes in his list of the fish propagated by the New York State Conservation Commission, but later reports indicate that the Commission distributes them to some extent.
Needham ('22) names the bullhead as one of the most valuable species of Lake George. In the same report Moore says concerning the young: "Their period of active feeding begins when they leave the cover of the nest and under the protection of either one or both parents spread over the rim of the nest in quest of food. At this time they are about 10–12 millimeters long and are as black as tadpoles. . . . Their first meal consists of the minute animal organisms which are developed in the vegetation of the spawning grounds. These are the minutest of the water fleas and crustacea together with very small midge larvae. They remain the prominent staples until the fry are about two weeks old, though by this time they do not confine themselves to the minutest forms. At about the age of two weeks the schools scatter and the individuals behave much as do the older bullheads in their food gathering, scooping up algae, debris and the like along with the animal life."

The bullhead is of wide natural distribution but it affects still waters,—lakes, ponds and "dead waters" of streams.

**The Whitefishes.** The whitefish family comprises a great many nominal species or races, particularly those commonly designated as "herring," and many waters of northern New York contain one or more of them.

Some of them are occasionally taken on a baited hook or on a fly. However, they are not generally recognized as game fish and are not propagated and distributed as such.

Not much is known concerning the life histories of any of the whitefishes, but the Federal Government and certain States have extensively propagated some species. Bean lists four species as distributed to some extent by the New York State Conservation Commission. These are the common whitefish, the round whitefish or Adirondack "frost fish," Lake Erie herring and greenback herring. In later reports of the Conservation Commission the tullibee is also mentioned.

Special effort should be made to study the life histories and conditions of environment of the various important species.

1. **Common Whitefish.** Bean ('16) wrote: "The common whitefish, probably the most esteemed of all fresh-water food fishes, is found in Lake Ontario, some Adirondack lakes, Otsego Lake, and several other lakes in the central and western parts of the State. It is an inhabitant of cold, deep water, coming to the shallower parts to spawn. It may be taken with hook and line, but is usually caught with nets. The food of adults consists largely of crustaceans, and also mollusks, insect larvae, and small fish; that of the fry and young fish is almost wholly small crustaceans.

"The fry are distributed in March and April and should be planted in the shoal parts of lakes."

These instructions concerning the planting of fry afford no advance over the procedure of many years ago.

Thirty years ago Professor J. Reighard wrote concerning whitefish in the Great Lakes ('94): "Several hundred million ova are
taken annually and placed in the hatcheries, and of these usually from eighty to ninety per cent are hatched and placed in the waters of the Great Lakes, 165,000,000 in Lake Erie alone in 1888.

“This is very nearly all that is known about these young whitefish. About their food habits we know only that in captivity they eat certain species of Crustacea. Whether in their natural habitat they eat other animals in addition to these Crustacea or in preference to them we do not know. It is uncertain at what age they begin to take food, or how much they require. We do not know their natural enemies. We do not know whether they thrive best in running water or in standing water; in shallow water or in deep water; whether at the surface or near the bottom. What changes of habitat or of food habits the fish undergo as they grow older is a still deeper mystery.

“Our problem is to place young whitefish in the Great Lakes under such conditions that as large a number as possible of them shall grow into adult fish. It is clear that of one of the elements in this problem, namely, the whitefish, we know but little.”

Forty years ago Professor Forbes (’83) found that young artificially hatched fish in captivity would eat certain forms of minute crustaceans, but since that time scarcely anything has been learned of the food of young whitefish under natural conditions, although some advance has been made in the knowledge of the food of the adult fish.

Hankinson (’14, ’16) records the food of little whitefish, 3 to 3.5 inches in length, which were found in a lot of small “herring” of similar size on a shoal of Lake Superior. He said that he was unable to find in the literature a record of whitefish beyond the fry stage as small as those taken at Vermilion. The young whitefish were found to be eating entomostracans freely, and this appeared to be the chief food of those collected. Midge larvae (Chironomus) were found to be taken by them in important numbers.

2. Round Whitefish; Frostfish. Bean (’16) says that the round whitefish is found in the lakes of the Adirondack region and that its food habits are similar to those of the common whitefish. “The fry are ready for distribution in March and April, and are usually planted by the Commission in the waters from which the eggs were collected.” No definite instructions are given for planting the fry, and there appears to be no specific information concerning the food of the fry. Very little information concerning the habits of the species is available. In certain waters, as in Maine, this species ascends tributary streams of lakes to spawn. How long the young remain in the streams after they are hatched does not appear to be known. Basing the recommendation, however, upon the fact that the fry’s first existence is in the stream, other things being favorable, it is best to plant fry of frostfish in tributary streams.

Hankinson (’16) states that this species was found common on the deeper part of the shoal near Vermilion (Northern Michigan). Those taken were of edible size, a little over a foot long. Two
typical specimens opened had been eating principally amphipods; one had these only in its stomach, and the other had miscellaneous insect remains in addition to them.

3. Lake Erie Herring. According to Bean this species is found chiefly in Lake Erie. The fry are ready for distribution in March and April and are usually planted in the waters from which the eggs are obtained.

4. Greenback Herring. Bean says that the Greenback Herring occurs in Lake Ontario and Cayuga Lake, and that the fry are ready for distribution in March and April and are usually planted in the waters from which the eggs were collected.

5. Tullibee. The tullibee is the whitefish formerly abundant in Onondaga Lake and common either as a native or by introduction in Oneida Lake. Bean ('03) quotes from James Annin, Jr., on the spawning of the tullibee in Onondaga Lake as follows:

“They generally commence running up onto the shoals about November 15 and the season extends into December. They come up to the banks or gravelly shoals and spawn in from three to six and seven feet of water.”

This account would indicate that newly hatched fry should be planted in such places, provided they have been found to afford similar conditions to those of the natural spawning beds.

There appears to be nothing definitely known concerning the life history of this fish.

Procedure for Planting Young Fish. The method or technique of planting fish as described by Bean ('16) pertains mainly to trout and streams, although some of it applies to standing waters as well. As the present writer has had but little experience in the actual planting of fish he attempts to add nothing to Bean's instructions and accordingly extracts therefrom the most important items.

Essential Preliminaries. “Plans for stocking should be made during the driest part of the preceding season. Only streams or parts of streams that have not then dried up or become stagnant should be considered in the plans for future planting. Every detail regarding the adaptability of the stream or lake for the fish that it is desired to plant should be carefully considered. Foresight in this direction will save many fish that otherwise would be lost.”

Planting Points and Food Supply. “The two chief requirements of young fish are protection and food. They need protection from predacious enemies, freshets, droughts and disease. In general, for stream-inhabiting species, the headwaters furnish the most suitable planting points. Here the larger fish are not apt to be present to prey upon the fry. Freshets are not so strongly felt there, and are less likely to wash the small fish downstream. Moreover, the chances of pollution are much less. Care must be taken, on the other hand, not to plant the fish in streams or headwaters which may dry up in time of drought. For the young of lake fish the most favorable situations are generally the shallow waters near
shore, or on shoals or reefs. In either case, whether dealing with brook fish or lake fish, it is well to discover, if possible, the natural spawning beds, and to plant the young in or close to such places; for it is reasonable to suppose that each species has come to choose for its spawning grounds the places that are most suitable for its young to hatch and live in. These situations are likely to be supplied with the natural food that the young require. As the fish grow they will gradually work their way into the deeper and wider waters inhabited by the adults.

"While we have only a meager knowledge of the food of fish at the earliest periods of their lives, we know in a very general way what the adults of the commoner species feed upon. It is of particular importance therefore, when introducing any species into waters where it has not occurred previously, to ascertain whether a suitable supply of its natural food is available."

**Care During Transportation.** "The fry and fingerlings of most species are distributed in spring and early summer. The cans containing these young fish are accompanied from the hatcheries by a messenger, who cares for them during the railway journey. The water in the cans must be kept constantly aerated, so that the fish will not suffocate from lack of oxygen. Unless special apparatus is provided, this is done by hand, water being dipped up from the top of the can and allowed to fall back from a height. Such attention is required at least every half hour. The water must also be kept cool, with the use of ice, if necessary. The applicant is notified by telegraph on what train the fish will be shipped. If he does not meet the train, they cannot be delivered, but are carried on by the messenger to the next station where an applicant awaits a shipment.

"The same care is required during the journey from the railway station to the streams that is given by the messenger of the train. Under no circumstances must the fry or fingerlings be kept in the cans over night without attention. It is necessary to take them directly to their destination and plant them at once. They should be protected as much as possible from jarring while being transported by wagon, to prevent injury to the young fish from being thrown against the sides and bottom of the cans."

**Importance of Water Temperature.** "Just before actually placing the fish in the water, attention must be given to the temperature of the water in the can and in the stream. If this vital point is neglected, the entire planting may be for naught, for a difference of only a few degrees between the two waters will kill young fish. A twenty-five cent dairy thermometer will show whatever variation there is. However small the variation may be, the temperatures must be equalized by dipping water from the can into the stream, and from the stream into the can, a little at a time. Another method is to stand the can in the stream, but this takes much longer." Doing both at the same time would facilitate the equalization of temperature.

**Planting.** "When the temperature is right, the can may be
emptied. The fish may be dipped out, or carefully poured from the can. In the latter case, the mouth of the can should be held no more than a few inches above the stream, so that the fry will not be jarred by the impact of the water. The fish should be spread out as much as possible, some being planted in one place, and others a little farther away. No more than 500 fingerlings or 2,000 fry should be planted per mile in a small stream. The food supply will be in danger of exhaustion in over-stocked waters.”

*Artificial Stream Pools and Side Pools.* “One of the very best means that can be adopted for the protection of the fry of stream fish is the building of artificial stream pools. These are formed by damming up the headwater rivulets and little spring creeks. A number of dams, built of loose rocks, logs or boards, may be advantageously placed a short distance apart on the same stream. They not only insure a good water supply for the young fish in dry seasons, but also prevent them from being swept away by spring freshets. They also largely increase the area in which the natural food supply may grow, and over which the fish may forage for this food. By remaining in these pools near the headwaters, the fry gain security from the larger predacious fish that lurk downstream. After attaining a suitable size, however, they will of their own accord seek the lower courses. Probably in most cases the stones or other materials for building the dams may be found on the spot. The structures need not be more than twelve or fifteen inches in height. The tops of the dams should be as narrow as possible, and the water should fall over them in at least one place, in order that such fish as trout may leap over the obstruction without difficulty in ascending the stream to spawn in the fall. The beaver dams in the Adirondacks make stream pools on a large scale, and have greatly improved the trout fishing on the streams where they are located.

“Side pools may be formed on large streams either by excavating suitable basins near the streams and diverting water through them, or by taking advantage of natural hollows and basins. The inlet from the stream and the outlet of the side pool should be screened to prevent the entrance of fish from the stream, which would prey upon the fry in the side pool. These pools, if sufficiently large, will provide enough natural food for a considerable number of fry. The fingerlings should be allowed to run into the main stream in the fall. On the headwaters of small streams, where large fish are not found, pools of this sort, that will require no screening, can often be made at small expense, and the fry in them will require no attention. Shade can easily be provided on the banks of side pools by the planting of willows and black alders. A few large rocks under which the little fish can hide and boards supported from the bottom on stones, and weighted down with rocks to prevent floating away, will complete the arrangements.”

This may be a convenient place to call attention to a method of planting brook trout which was adopted by the Massachusetts Com-
mission in 1920. Mr. W. C. Adams ('20) writes: "A method of
distribution new in Massachusetts was adopted this year,—the
planting of eyed eggs in wire baskets for hatching in streams which
it is desired to stock.

"The trout ridd, or artificial nest, has had its chief development
in Europe, where for years it has been the means of stocking the
inaccessible mountain streams. The method therefore has been
thoroughly tested.

"The first requisite for success is to make the plants under the
proper conditions. A long stretch of stream is required, spring-fed
to keep it free from ice and to give a suitable temperature. It should
be shallow with a fairly good current and numerous shallow eddies,
but not many deep pools which would harbor large fish.

"The eggs are placed in wire baskets or trays, containing about
two square feet of surface, built of heavy mesh wire of such size
that the eggs will not fall through. The proper age at which the
eggs should be planted is from one to two weeks before they are
ready to hatch. They are spread evenly in the baskets, in numbers
varying from 500 to 1000 to the square foot. The tray is placed
in the stream, set on small wooden uprights forced into the bottom
of the stream and held about two inches above the bottom, so that
the water entirely covers the container and its contents. The flow
should be such as to give complete circulation in every part of
the tray. After the basket is placed in position it is protected and
concealed by covering it with brush or evergreen boughs in the form
of a lean-to over the stream.

"As the eggs hatch the fry drop through the mesh of the
basket into the silt, and lie quietly on the bottom until they begin
to feed. When that time comes they rise and scatter far up and
down the stream in search of suitable feeding grounds. This simu-
lates closely the natural method of propagation."

REGULATIONS FOR PROTECTING FISHERIES

In restocking waters, having ascertained to which kinds of desir-
able fishes the waters are suited and having stocked them with the
number which the conditions warrant, the main problem then is that
of regulation, conservation and the maintenance of a supply commen-
surate with the demand made upon it. To these ends, for many
years it was a common custom to close stocked waters for various
lengths of time for the purpose of giving the fish time in which
to grow and establish themselves.

Closing Stocked Streams. In many instances streams tributary
to lakes or to larger streams, have been permanently closed, upon the
assumption that those tributary streams were nurseries for the
larger bodies of water. The majority of cases of both lake and
stream tributaries pertained to the brook trout, although occasionally
other species were so treated.

In some instances of temporary closure the benefits of it have
accrued to a few individuals instead of the many for whom the
benefits were intended. The accumulation of trout of several years have been fished out by those who were able to get the best chance to fish, in the first few weeks of the open season. The policy or law of the state usually is to stock public but not private waters, but in such instances as just mentioned, the closure has practically made the stocking a private one. The state has thereby been put to considerable expense to produce fish for a few individuals. Hence the dissatisfaction amongst other trout fishermen because those first on the brook had “beaten them to it.”

In the cases of permanent closure there often appeared to be a decrease rather than the looked-for increase of trout. So the question arose as to the practical use of closing such waters.

Aside from the inequitableness referred to, the question of the temporary, or permanent closing of waters involves several other considerations, one of which is economy. The fact that a body of water will support a certain amount of organic life and no more, has been emphasized in this publication, and in others. A brook, for instance, is capable of producing food enough to adequately sustain a stock of brook trout in proportion to the area, if in other ways suited to the fish. The size attained by the trout depends in a great measure upon the quantity of its food supply. If, as elsewhere indicated, the trout area is over-crowded, the fish will not attain the maximum average growth which they otherwise might attain. Investigations or ecological studies of trout have not yet reached the point where we can correlate the available food supply with the exact or even approximate number of fish that should be planted in a given area. It is usually the custom to consider the size of the stream and guess at the number of fish which should be planted, in order that it may be adequately stocked. At least that is the custom when other influences are not brought to bear. In any event the allotment has been in the past, and continues to be, when possible, a very liberal one, and one that is likely to comprise more fish than the area can sufficiently provide with food. In a discussion of this subject Dr. Nathan Fasten, of the Oregon Agricultural College, calls attention to a possible result of closing a stream (Fasten, '22). He says: “My observations along this line have convinced me that this [closing of a body of water to fishing] is an erroneous practice. In the first place, closing down a stream makes for a rapid multiplication of fish so that the available food supply soon becomes inadequate to maintain all of them. A fierce struggle for existence ensues in which many of the weaker, but nevertheless desirable fish, are killed off. Even those that remain appear to be starved for lack of food.”

In the present writer’s experience, while some of the larger fish may appear more or less emaciated, the general tendency under overcrowded conditions is for the fish to remain small, and to attain breeding maturity while yet small, and consequently produce fewer or inferior progeny, although it is conceivable of the food supply becoming so depleted that the trout would resort to cannibalism and even starve.
Dr. Fasten mentioned another undesirable condition which might arise from congested conditions within a stream. That is, a rapid spread of any parasitic infection which happens to make its appearance among the fish, and he indicated that parasitism might be engendered under "closed down" conditions, in that the undisturbed shores would afford a habitat for fish-destroying birds and other animals which not only kill large numbers of fish, but may also be the means of disseminating various parasitic organisms among them.

**Protective Methods.** Bean ('16) wrote: "The strongest ally of stocking is protection. Without the latter, the former will quickly be nullified. The game protective force is constantly on duty to prevent illegal fishing in all of its forms, and accomplishes results which place it in the front rank among similar organizations in this country. It should be understood, however, that fully effective protection is dependent upon public cooperation. The force of any law is determined largely by the sentiment of the community to which it applies, and in a community which does not countenance game law violations the violations are relatively few. In accordingly behooves everyone interested in better fishing to foster the development of a clean and sportsmanlike spirit regarding the observance of the fishing laws. Without such moral support and active cooperation on the part of sportmen, the 450 square miles which every protector must police on the average cannot be thoroughly supervised. It should be realized by those who are doing the stocking that it is quite as important to effectively protect their fish after they are in the water as to place them there properly at the start."

Laws intended to protect fish should be based upon positive knowledge concerning the fish to be protected. Unless they are framed in accordance with such knowledge, no matter how rigidly and thoroughly they are enforced, they are liable to fail of their object, and even result in harm to the fish for the protection of which the law is enacted.

It is generally conceded that fish should be protected during their breeding season. Yet there are those who maintain that it is no more harm to kill a fish during that season than at any other time. They say an intensive fishery at any season destroys just as many eggs and consequently progeny as if they were all caught in the breeding season. This is false reasoning as applies to fish in general. It is true that commercial fisheries for certain kinds of fish are conducted profitably only at the time the fish are on the way to the breeding places, and if the fishery were prohibited none of those fish would be available for food. But there are many examples of depleted fisheries which are attributable to too intensive fishing at that time.

It is easily seen why this is so. It is quite clear that if no fish are produced to take the place of those caught the future supply is reduced. Fish hatcheries are supposed to remedy this situation.
But what is to be done when breeding fish are not obtainable to provide the eggs to hatch? Breeders must be maintained or the fish will literally as well as figuratively "go to pot." The logical conclusion would seem to be that there must be sufficient breeding fish left to maintain the supply.

Mention has already been made of the failure of the egg supply of a certain fish and the impending failure in the case of others. Another instance is related by E. W. Cobb, Superintendent of Fisheries of Minnesota, in an article entitled "Last Stand of Pike-perch in Minnesota Lakes." He wrote ('22): "Let us look for a time at the history of this fish during this period [past years] and see as nearly as possible what the facts are today. In spite of the efforts being made for its increase the species has rapidly fallen off in numbers until today many of the States in which it was native can no longer secure eggs and others can secure them only in limited numbers. . . . The southern part of our State (Minnesota) is now and has been for some time in such condition that artificial propagation would be impossible except for the supply of eggs taken in the northern part of the State. The sections from which eggs can be secured have narrowed down to the northern part of the State, and the lakes here are more accessible and more heavily fished than the more southern lakes even five years ago. . . . Notwithstanding these efforts it is realized that more must be done if the supply is to be maintained. We now have no really inaccessible waters and a constant procession of tourists pass from and through southern Minnesota to the north where fishing is good. Many come from the West, and from as far north as Winnipeg. Besides this the people from villages and cities as well as those living in the immediate district spend days and weeks by the lakes which could not be enjoyed but for the auto which is available to nearly all. In fact a veritable tidal wave of people seems to be sweeping over the wilder sections of the State, and at times to be about to destroy our best fishing grounds.

"The question is of course, what shall we do about it? Shall we increase our efforts in behalf of those lakes now containing a good supply even though it might seem at first thought to be to the detriment of lakes further south? It will not benefit our southern lakes to follow a policy which will eventually result in doing away with the only available supply."

As remarked elsewhere, the number of anglers cannot be controlled but their operations may be in one way or another. But such regulations sometimes appear impossible owing to conflicting interests, as in the above instance of north and south Minnesota. Those interests must be harmonized or failure of the fisheries is inevitable. Harmony is attainable only through enlightenment of the conflicting interests as to the facts, and the real facts become available only by acquiring a full knowledge concerning the fish and its "interests." The fact may prove to be that southern waters were fished out in spite of efforts to maintain the fishing. That is probably not the whole cause of the present depletion. If
it is the whole cause, in spite of the “past intensive” efforts to maintain a stock, the pikeperch in Minnesota surely has its “back to the wall.” The method of handling the situation must be modified in the light of positive knowledge concerning the lakes and the fish, and by regulations of the fishery.

Without basic knowledge concerning all conditions pertaining to fish and fisheries, legal regulations and restrictions, while they may sometimes help, in the long run often prove ineffective. A regulation that may be effective in one locality may not be in another; or one that will apply to one kind of fish is quite sure not to apply to another even though it be a closely related form. Yet one general law is often made to cover a whole group of fishes, such as the blackbasses and other members of the sunfish family, or it may be the pikes or even the trouts.

Concerning the trouts it may be said that a law protecting the brook trout in its breeding season will not afford protection to spring spawning trouts unless the closed season is extended to cover the breeding seasons of those forms.

There are often purported protective laws applying to fish at other seasons than the breeding season. These may pertain to place of capture or method of capture, or something else. Some of these laws frequently appear to favor one or another class of fishermen, as for instance the restriction to fly-fishing, which meets with objections from the users of natural baits. The custom of fishing with bait in certain places where fish are known to congregate at some season of the year has been a matter of controversy among fishermen in some localities, and laws prohibitive of deep water or so-called “plug fishing,” and “advance baiting” have been enacted.

Laws have been passed restricting the fishing for certain fishes to a single hook, thus eliminating multiple hooks and gang hooks. In some instances these have been repealed through the influence of fishing tackle dealers. So we might go on and recite a multitude of laws which do not always fit the case and seldom meet with general approbation.

So, to repeat, appropriate laws and regulations must always be based upon accurate knowledge of the fish and the conditions affecting them, accompanied by education of fishermen whose interests appear to conflict.

There must be regulations even though they apparently affect some people or some localities disadvantageously. The adage, “You cannot eat your cake and keep it too” is well stated in the words of a former Federal Commissioner of Fisheries, thirty years ago, (McDonald, ’94, p. 16): “We must not, however, be unmindful of the fact that the prosecution of the fisheries without reasonable and necessary restraints, is sure in the end to make adequate reproduction by artificial methods impracticable by obstructing or shutting off the sources of egg supply. Protection, therefore, and reasonable regulations as to the times and methods of fisheries is just as
essential for the maintenance of our fisheries as is the largest measure of artificial propagation."

**Legal Sizes for Catching.** Bean ('16) says: "Inquiries indicate that there are many persons who do not understand the exact significance and necessity of the six-inch law for brook trout, and of similar regulations regarding the size at which other species may be taken. Until an individual of a given species has reached the prescribed size, it has never spawned; and if all the individuals were caught before they had arrived at the spawning age, it is perfectly plain that the complete extermination of the species would be a matter of only a short time. It is therefore to the interest of every angler to see that under-sized fish are not destroyed. Every food and game fish should have a chance to spawn at least once before being taken."

The principle conveyed by the foregoing paragraph is sound in its general application, but it seems to the present writer that the size limit for trout, at least, is one for local regulation, or rather in imposing a size limit local conditions should be considered. In some localities the brook trout, and possibly other species, are known to attain maturity at a size below the legal limit of six inches, and never reach a much larger size. In other instances they attain a much larger size than that legal size limit of capture before maturity.

Under favorable conditions trout grow rapidly, but there is no way of answering definitely the frequent query, "How long does it take a trout to grow to a certain size?" According to circumstances a trout may attain in two years only three or four inches in length, or it may attain ten or more inches. Under certain conditions, as in circumscribed localities like a small brook, trout often reach maturity when only four or five inches long and still bearing the marks of a young fish. Again, mature trout have been seen of not over five or six inches in length in which these marks of youth had nearly or quite disappeared, and the male fish was a facsimile of its larger brother of the lake. Also trout of nine and ten inches still immature have been seen in lakes and streams of considerable size. For example, "large" trout, sexually immature, were noted on October 18, 1916, in a large pool below the dam at the foot of Matagamon Lake, East Branch of the Penobscot River, Maine, by the present writer who caught 14 trout from 61/4 to 101/2 inches total length, all of which were immature. Apparently they never had spawned, for there was no second crop of visible eggs as is usual when the fish have spawned once. Six of the trout were males from about 9 to about 101/2 inches total length and eight more were females ranging from 61/4 to 101/2 inches total length.

Writing of trout in the Connecticut Lakes region in Northern New Hampshire, the author (Kendall and Goldsborough, '08, p. 53) said: "Every stream and pond in the region contains more or less trout, varying in size according to the body of water and in number according to the accessibility and ease with which the water is fished.
Many of the little mountain brooks literally teem with small trout, frequently too small to be legally caught, yet some of them are adult fish and probably will attain no larger size. Small brooks of whatever character, from mountain rivulets to sluggish bog brooks, seem to contain trout. Hundreds of these trout are caught every year, and it is a question whether any harm is done thereby, for while a few may reach the lakes or river and become large fish, most of them remain in the brooks, reach maturity, and spawn while still small fish."

Need of Fish Preserves. There is already an actual failure of the egg supply of some species of fish and there is an impending failure of the supply of still others. The most serious problem appears to concern the landlocked salmon, lake trout and brook trout in the Eastern states, and it has been seen that the pike-perch is similarly a matter of concern in Minnesota. Like conditions with this latter species and even others may obtain in other localities. If such conditions are not already apparent they probably will be sooner or later.

Of course, it is quite obvious that the species of most limited natural distribution, are the ones most imminently threatened. Already one or two such species have been practically exterminated. The case of the landlocked salmon has already been cited and emphasized. The lake trout and brook trout are more of local than general concern just at present. But it may be considered as significant that the United States Bureau of Fisheries and the New York State Conservation Commission now buy many of the brook trout eggs which they hatch and distribute, from private or commercial concerns. Probably this is due to the fact that, while commercial trout eggs are expensive, the cost is less than it would be to go to the remote waters where the fish may still be common. The immediate wild waters, as has been shown, do not now afford an adequate yield. The trouble encountered and problems that arise concerning brood stocks, eggs and young trout in many hatcheries, taken into consideration with the receding sources of supply of wild eggs are surely ominous and merit careful thought.

It is quite noticeable that most of those species which are not stripped and hatched "artificially," but which are allowed to breed naturally, and are protected and assisted in the process, afford fewer and less serious problems of maintenance of the stock, than do those species previously cited, and some of them are more amenable to pond cultural processes. The foregoing facts give rise to the warning that something in the direction of conservation of the egg supply and the breeding stock must be done as soon as possible. To that end the suggestion here made is that the most practicable measure would be the establishment of natural sanctuaries for each species concerned, similar in purpose to game sanctuaries. In other words a natural body of water might be selected, which would afford sufficient area and volume, and adequate conditions for the maintenance of a brood stock of each species with which the State is
concerned. The selection should be based upon a scientific examination, that all essential conditions may be assured. In such waters no fishing should be allowed and the waters should be preserved for fish cultural purposes. It would be possible to manage such a reservation so that a future egg supply would be practically permanent.

**Game Fish versus Food Fish.** In 1903, an agent of the United States Fish Commission canvassed the interior waters of the State. In his report (Cobb, '05) he said: "New York is dotted with numerous lakes, many of them such as Oneida, Champlain, Seneca, and Cayuga, of great extent, while there is a veritable network of rivers, creeks, and canals throughout the State. The principal aim of the authorities has been, as far as possible, to confine the fishing in the interior lakes and streams to sportsmen, who are attracted not only from all parts of New York, but from other States and even from foreign lands by the excellent fishing afforded in these waters. Such pleasure seekers are usually liberal, and the sums expended by them net a larger profit to the community than would be obtained by the unrestricted use of fishing apparatus on the part of local fishermen. It has been estimated that the sportsmen leave behind them, in the hands of the railroads, hotels, guides, boatmen, etc., several million dollars each year."

In this bulletin it has been previously indicated that in the majority of interior waters the angling sport has come to be regarded as of paramount importance, although the general public "pays the freight." Without doubt there are large numbers of anglers but there is no angling license fee. As concerns productive game fish waters under present conditions, it is no doubt true, as claimed, that the game fishes of the inland waters of the State are a far greater asset than a commercial fishery in those waters would be. But there are over fifty species of fishes inhabiting the interior waters of the State which are or might be important food fishes, and many of them are not accounted as game fishes and do not attract the angler. Such fishes are more common in the larger lakes rather than in the streams and small ponds. As has been shown, only a few of the fish indigenous to the State are propagated or raised and distributed by the Conservation Commission.

It is contrary to law to fish in many of the interior waters by any method other than with hook and line (figures 42, 43, 44). Under present conditions this is doubtless a good provision so far as the fish which can be taken by those methods are directly concerned. But many excellent species of food fish cannot be so taken effectively, if at all; and in practice these are usually taken illegally, for licensed netting is restricted or forbidden in certain waters. Besides these species there are others, so-called coarse or cull fish, which are not generally held in favor as food fish, and some of which are reputed to be harmful in one way or another to game fishes. Their destruction has often been advocated by anglers. Most of those species are really good food fish, and, as a matter of fact, are locally esteemed as such.
Fig. 42. Angling in the Oneida River, near Caughdenoy, New York.

Fig. 43. Angling in a meadow trout stream in Erie County, New York.
Fig. 44. Catching yellow perch through the ice. Oneida Lake, New York

Fig. 45. Eel weirs, Oneida River, near Caughdenov. New York.
In connection with some waters, whether or not it is economy to restrict fishing to one or two game fishes when the waters abound with other fishes valuable for food, or where, if once numerous but now depleted, they can be replenished, is a question.

Food resources are of vital importance in these days, as is recognized by all. It would seem that although a lake may be yielding a good crop of game fishes, which represent value in dollars and cents, if that lake can be made to yield a supplementary crop also representing monetary value, it would be good business to develop it, at least for more or less local consumption, according to the magnitude or character of the fishery, providing it is not detrimental to the principal crop (figures 42, 44, 45). Moreover attention has been called to the fact that the general game fish supply is decreasing and its complete failure is only a matter of time unless something constructive is done to check the decline. The interrelations and interdependence of animal life in a body of water has already been discussed to some length in this bulletin, as well as in many other publications, and it should not be necessary to repeat it here; but it may bear repetition to state that the decline of game fish may not be wholly attributable to over-fishing, but that possibly it has been hastened by an over-increase of some other species which the decrease of game fish has permitted, and when nothing has been done to check the less desirable kinds. In some instances, too, the over-increase may have been reflected at last upon those species so that there is general depletion. So, as has been shown, readjustment of the balance is necessary. To ascertain the facts, in order to attempt readjustment, calls for an investigation. It is rapidly becoming expedient that an effort at readjustment be made, for so far as the sport of anglers and food supply is concerned it becomes not only economic waste but in some instances possible obstruction to the conservation of some of those fishes for the preservation of which present laws are intended.

It would be both an economical and a conservative measure as concerns the game fish, if some means could be devised by which the people of a region could get the benefit of such surplus fish. Formerly certain privileges in that direction were granted, and to some extent the same may obtain today. Nearly twenty years ago J. N. Cobb ('05) wrote: "Whenever possible without injury to the sport fishing, the State has permitted the use of nets to some extent, principally for the purpose of reducing the abundance of the commoner species of fishes, which when in excessive numbers, do serious damage to the game fish by devouring spawn and fry. It has been an exceedingly difficult matter to guard waters so extensive, however, and as a result there is much illegal fishing." Undoubtedly in some localities there are those who get the benefit of any fish that can be caught by proper or illegal means, and under present conditions enforcement of the laws is difficult, yet it does not seem to be a rational or logical procedure to deprive everyone of the opportunity to augment the food supply because a few abuse the
privilege, especially when by a study of conditions, enlightenment of public opinion concerning the exact situation might become possible, and thereby abuse of the fishing privileges might be reduced.

The present comparatively ineffective efforts to save the game fish is a matter of concern to many, but there are many more who have no interest in those fish or any other fish, as game fish. Their interest is in the fish as a source of profit or food. Some of them, perhaps many of them, in no way, so far as they can see, share in the “millions” which anglers spend for their sport. There is therefore a conflict of views between them and the angler which has given rise to the present vexed questions. Bean (11) said: “It is unfortunate but true, that the life of the inland lakes of New York, numerous and important though they are, is as little known as that of some of our remote possessions. New York ranks among the greatest of the states in the value of its fisheries and its waters contain undeveloped resources of unusual importance. We know little more than the names and spawning seasons of our common fishes. The interrelation of species in their effects one upon the other is almost a sealed book to us. In fish culture the State is occupied with only about thirty species [including marine] and these are under observation for the most part at the spawning season only. What is going on in the open waters of our streams and on the bottoms of our lakes is little understood, and yet it is of vital importance to the success of our work. The State ought to devote more time and money to the study of its natural aquatic resources. Such investigations would yield unexpected and most gratifying returns. It is time that the importance of the fisheries to the general public as well as the angler was fully recognized and acknowledged.”

It is a recognized fact that the general public bears the expense of fish culture and the burden of protection of the game fishes. It is true that the anglers are a minority of the general public, and being a part of a whole, there should be no conflict of interests as concerns public welfare. The anglers have undisputed rights, but the majority have certain rights also, so far as the management of the public resources is concerned. One of its particular rights is that of deriving some benefit from the expenditure of public money. This is an important fact which appears to have often been overlooked, disregarded, or underestimated. While this may not be the proper place to say so, it is high time that it be said, that this just relation of the whole of the people to a part of the people, is an imminent economic problem of which the State will have to take cognizance in connection with the interior fishing waters:

The benefit to be derived by the fish-eating but non-fishing population from public money well spent in development of the resources of the interior waters lies in the products of that development. Many of the largest lakes of the interior once contained an abundant supply of whitefishes of several kinds and some of them perhaps do even today. Those that do not might be capable of such development through intelligent management. While the State has
propagated some of them and planted them in interior waters, they
have usually been subject to the law restricting the method of
capture to ordinary angling methods. The question concerning
these fish came up during the late war.

The Seventh Annual Report of the Conservation Commission,
State of New York, for 1917 (pp. 45-47), says: “A careful study
of the work that has been done during many years in the stock-
ing of many lakes with whitefish leads to the conclusion that the
policy of the State with regard to this fish has never been thoroughly
worked out. While the whitefish is not to be classed for a moment
with a number of other species as regards destructiveness to spawn
of other fishes, it nevertheless is a fact that the whitefish does eat
spawn and young fry in lakes inhabited by trout. Moreover an
examination of a number of whitefish stomachs indicates that in
some of these lakes the principal food of the whitefish is the same
as that of the trout existing under similar conditions. Thus it is a
competitor of the trout and in trout lakes that have been intensively
stocked with whitefish the latter is unquestionably being fostered to
the detriment of the trout. In such lakes, however, most of which
are in the Adirondacks, there is a more serious argument against
practices heretofore in force. Though the State has for years been
stocking these lakes with whitefish, it is nevertheless contrary to
law to take them, other than in the Great Lakes, except by angling.
In a limited number of the Adirondack lakes whitefish are caught
by angling, but in many others they are not taken by angling at all,
and thus for all practical purposes are given protection throughout
the year.

“It is important that the entire policy with regard to whitefish
be revised and that the taking of these fish commercially be per-
mitted in some of the lakes where they are abundant, thus making
it possible for the public to obtain some benefit for the expenditures
which have been made in stocking these waters. In other lakes,
where it is not advisable to permit commercial fisheries operations,
it would seem that the whitefish should be able to maintain them-

themselves by natural reproduction in sufficient numbers to compensate
for all that may be removed by angling alone, and that annual
stocking hereafter is unnecessary in those waters. In other words,
the Commission believes that the whitefish product of the hatcheries
should be planted almost exclusively in waters which are fished
commercially. Plans to this end are being developed.

“The Adirondack frostfish is one of the minor whitefishes which
is abundant in some of the Adirondack lakes. It has been propagated
by the State for years. It is not taken by angling, however, and
it is unlawful to fish for it by any other method.” It therefore seems
futile to continue the propagation of this species unless some means
are found whereby they may be caught and utilized as food fish.
The tullibee, another species of whitefish, has been extensively
propagated at Constantia and yet the public has derived no benefit
from the expense thus incurred. For this reason the work was
discontinued during the last spawning season. Attempts are being
made by the Commission, however, to develop a method for establishing and regulating a commercial fishery for this species and if they are successful its propagation will be resumed.

A few years before this, the whitefish question arose in Vermont. A legislative act of 1912 gave the Commissioner of Vermont (Titcomb, '14) "power to investigate the waters of Lake Champlain with a view to ascertaining whether it is practicable to take whitefish, commonly called shad, without seriously depleting the waters of fish ordinarily taken by the angler. With a view to carrying out this investigation, Dr. H. F. Perkins of the University of Vermont, was placed in direct charge of the investigations. A professional fisherman from Lake Erie was employed to operate nets.

"Through the courtesy of Hon. Hugh M. Smith, United States Commissioner of Fisheries, and Dr. H. F. Moore, Chief of the Division of Scientific Inquiry of the Federal Bureau of Fisheries, it was agreed that the investigation should be a joint one, that the survey might not only be one of investigation as provided by the state law, but in connection therewith that a biological survey of the lake should also be made."

In another paragraph the report says: "The investigations have not been completed. At the close of the present fiscal year Dr. Perkins is conducting a biological survey and further investigations connected with the whitefish inquiry, under the auspices and financed by the United States Bureau of Fisheries."

The United States Commissioner's report for 1914 refers to the work in a few words as follows: "A biological and fishery examination of Lake Champlain, commenced during the year in cooperation with the Vermont State Fish Commission, was suspended at the close of the summer, but will be concluded during the next fiscal year. It has as its primary purpose the determination of the feasibility of establishing a commercial fishery for certain species of fishes without detriment to the sporting interests on the lake which are a valuable asset to the people of Vermont and New York."

In subsequent reports there is no further mention of the biological and fishery examination of the lake. It apparently ended in 1914. Thus about the only conclusion reached by the survey was the conclusion of the survey. But the Commissioner of Vermont expressed the belief ('14, p. 69) that there were not sufficient whitefish in Lake Champlain to warrant a special commercial fishery for them, but further investigation might demonstrate that it was feasible. He went on to say: "It should be proper to take from Lake Champlain the largest number of fishes of all kinds that it is possible to annually remove without depleting the stock which makes the lake itself most attractive to the inhabitants of the border states, and which is an especially valuable asset to Vermont, in attracting anglers from abroad."

While it might be advisable to cease to plant whitefish in trout waters to which whitefish were not indigenous, it would seem
desirable to have some sort of arrangement by which these fish might become available for food, at least locally. Elsewhere in this bulletin the statement was made that no small body of water can afford an unlimited supply of food fish. If a market fishery is carried on in inland waters for sport fish, it is impossible for the stock to be naturally maintained. But under proper regulations such waters might be capable of yielding a limited, though appreciable and appreciated, amount of food fish without damage to the sport fish.

In northern Maine a chain of lakes contained, besides indigenous lake trout and brook trout and various "coarse fishes," three kinds of whitefish, all of which, excepting the trouts, were very abundant in 1903 when the present writer visited the region.

All three whitefishes ascended the streams connecting the lakes to spawn. In this locality no commercial fisheries were permitted, but occasionally the native French inhabitants were allowed to net the whitefish under restrictions during the spawning runs. In reporting upon the conditions as observed in the region the present writer said: "The fishing as now regulated is chiefly important to the sportsman, but the abundance of whitefish in a lake system of such extent suggests a possible commercial fishery under proper regulations, which would afford the inhabitants of Aroostook County at least, a delicious fish for the table, both fresh and cured. A limited net fishery, restricted to the summer months and to certain localities, would do no more damage, if as much, as is done by fishing on the spawning beds, which is now permitted." (Evermann, '05, p. 104.)

The State propagated whitefish, obtaining most of the eggs in this region, and distributed them in various waters of the State, with what object it is difficult to see, since the fishing was almost wholly restricted to hook and line, and but few were caught in that way. Now the sport fishing in the same region has greatly declined, for the same reason that it has in many other waters of the Eastern States. This subject need not be dwelt upon.

In New York State there are a number of extensive lakes some of which support a relatively large number of fishes other than game fishes, but as the report previously quoted states, they are not generally allowed to be caught by other than angling methods.

As examples of such lakes, let us take the largest two outside of the Great Lakes. One of these is wholly within the State borders. The other is of interstate as well as, to some extent, of international interest.

The first is Oneida Lake. As indicated by Adams and Hankinson ('16) the game fish as rated by the president of the Anglers' Association of Onondaga, in the order of preference, are: Small-mouth blackbass, pikeperch, large-mouth blackbass, yellow perch, pike ("pickerel"), and bullheads. The food fish as similarly rated by a fish dealer at Brewerton comprised a dozen or so species listed in classes: (1) eel, pikeperch, yellow perch, bullheads and
pickerel; (2) sunfish, black and red-fin suckers; (3) rockbass; (4) fork-tail catfish; (5) Oneida Lake whitefish or tullibee.

Their list of fish inhabitants of the lake includes at least 20 species of really excellent food fish, some of which are locally of little or no value as food, but which elsewhere are locally utilized.

Cobb ('05) indicated that other than some sorts of hook and line devices, the only apparatus employed in the commercial fishery of Oneida Lake in 1903 were seines, seven of which were in use. The only fish reported as caught by that means were 600,000 pounds of suckers valued at $12,000.00.

The total yield of all kinds of fish of the commercial fishery of that year amounted to 708,993 pounds valued at $18,088.00. The catch of suckers alone by other than hook and line methods amounted to over 87 per cent of the total catch.

In the face of these figures it would seem that Adams and Hankinson were justified in their opinion: "Clearly such a large lake should not be managed solely to the angling interests, but should produce an abundance of fresh food fish for this part of the State."

The second example is that of Lake Champlain. Evermann and Kendall ('02) listed about 50 species of fishes of all kinds, large and small, as recorded from the lake. Of these fully one-half are good, and the majority excellent food fishes, but some of them are now very rare.

In 1903, according to Cobb ('05) the commercial fishes of New York in this lake comprised only 9 kinds, of which the total catch amounted to 142,275 pounds valued at $10,245.00. Pickerel, bullheads and other catfish, yellow perch and smelt amounted to about 90 per cent of the catch. The apparatus employed in the fishery comprised hand-lines, set-lines, tip-ups, and spears. Only bullheads and catfish were reported as taken with set-lines; tip-ups took these same species besides yellow perch, pickerel and pikeperch. Only eels were taken with spears. On the Vermont side different methods prevailed. Lines and gill nets in addition to the apparatus used in New York were operated. Thirteen kinds of fish were reported, the great bulk of which were taken in seines, amounting to 490,552 pounds, valued at $33,179. No muskellunge or blackbass were reported, but besides those recorded for New York were sturgeon, suckers, sunfish, whitefish and lake herring. The total yield amounted to 528,682 pounds, valued at $37,669, of which pikeperch represented over 38 per cent. Smelts were taken on hand-lines only.

The total yield for Lake Champlain, exclusive of Canada, for which the figures are unknown, amounted to 670,957 pounds, valued at $47,914.

All of the kinds not ordinarily taken on hook and line apparatus, were caught in Vermont, comprising whitefish, lake herring, sturgeon and suckers, amounting to 119,686 pounds, valued at $7,737.00. Of these the suckers represented nearly 23 per cent.

Since 1903, commercial fishing on the interior waters of New York and in Vermont has been considerably reduced and restricted. Seines are no longer used in some waters where they were formerly
permitted. Some years ago Vermont ceased to allow the use of seines in Lake Champlain, and in justification of that restriction reports for 1916 as follows: "The results of fishing for pikeperch on Lake Champlain have been very satisfactory; not only the anglers who fish for sport are rejoicing at the improved conditions, but there has sprung up a legitimate fishing industry in angling for pikeperch and other lake fish for the market, some of these commercial anglers making a very good living in a very congenial employment. The improved angling conditions on the lake have created a demand for guides or boatmen."

"Most of the fish caught by market fishermen are shipped to New York, and it is often impossible for individuals to buy fish in small quantities for home consumption.

"The sentiment in favor of seining for pikeperch in the spring of the year has practically disappeared; more money can be earned by angling and it is available to all inhabitants of the state, while the wholesale capture of fish by the operation of seines is limited to a comparatively few people." (Titcomb, '16, Pt. 2, pp. 5–6.)

Again, the same report (Pt. 1, pp. 78–79) says: "Under Section 65, which authorizes the Commissioner to remove, permit or cause to be removed from public or private waters, fish which hinder or prevent the propagation of game fish or food fish, a large number of permits have been issued for the taking of suckers or mullets, not only in trout waters but in tributaries of Lake Champlain and other lakes where these species are not easily obtainable except during the spawning season in the spring of the year and not very desirable as food after warm weather."

On another page of this report (Pt. 1, p. 80) the following paragraphs appear:

"Permit to remove ciscoes [lake herring] from Lake St. Catherine were issued to fifteen persons. These permits were effective from November 20th to December 20th only [spawning season?]. Nets over three hundred feet in length were prohibited, and all fishing was done under supervision of a warden. The holders of these permits were either residents of Vermont or taxpayers on improved real estate in Vermont appraised at not less than $1,000.00.

"It is the policy of the Commissioner to issue these permits on the basis that the fishery resources of the State should be made as productive as possible and that if the experiment of issuing permits in these waters proves successful, the same policy may be adopted in other waters such as Lake Bomoseen in Rutland County and Seymour Lake in Orleans County. The main point to bear in mind is the protection of the more important species which are so important to the public in general."

From the foregoing it is seen that permits for commercial fishing usually have been granted with one or the other of two objects in view. The stated object of one is that of making the fishery resources as productive as possible. The other object has been
aimed at the destruction of species regarded as harmful in one way or another to the "more desirable fish," that is to say, game fish. Sometimes the two objects have been combined, or the first has been subordinated to the game fish interests.

Now just what successful outcome of the "experiment" of cisco netting in Lake St. Catherine was anticipated, is not stated. Judging from analogy, the month of open season for the netting was during the spawning time of these fish. If such was the case and the object was the destruction of the cisco the procedure would give full promise of success.

It appears that the bulk of the 600,000 pounds of suckers taken in 1903 in Oneida Lake was captured during the spawning time and was permitted for both of the aforementioned objects. Just what harm, if any, the ciscoes were to other "more desirable species" in Lake St. Catherine is not apparent. The alleged harmfulness of the suckers is based upon certain known propensities of those fish. But the possible, if not to say the probable, beneficial part suckers play in the natural economy of the waters has received no consideration.

As has been previously indicated, the destruction of these fish may defeat the intended purpose of their destruction. Even though a reduction of their numbers may be desirable in an effort to readjust a balance that has been disturbed by a reduction of the game fish to which the alleged harmful habits of the suckers or other fish pertain, their relation to other, perhaps even more harmful forms should be taken into consideration. For instance, the bowfin which occurs in both Oneida Lake and Lake Champlain may be even more destructive to certain game fish of those lakes than are the suckers, and the relation of the suckers to the bowfin may be such that the destruction of the suckers would intensify the harmful effects of the bowfin upon the game fish. This is purely hypothetical, however, for these specific relationships are not as yet established as facts. But even this possibility indicates the necessity of ascertaining every such fact concerning the fishes in any body of water before intelligent regulation of fisheries can be established, and rational procedures replace "experiment." It is possible that some other method of fishing at some other season of the year would produce the desired results of productiveness of the fishery resources, with sufficient but not undue reduction of any species.

The game fish situation in Oneida Lake appears not to have been improved although the sucker supply has been greatly diminished. What is wrong can only be conjectured. A step, if not to say a stride, in the direction of a solution of the problem has already been taken in the surveys to which previous reference has been made. What is now needed is continuation and amplification of the work already begun.

In the case of Lake Champlain neither game fish nor non-game fish are maintained to the economic maximum. In fact, some valuable species have been reduced almost to extinction, notwithstanding the fact that net-fishing in New York State has not been per-
mitted for a long time and has been prohibited in Vermont for a number of years. Undoubtedly there are other factors than fishing operative in the decrease of food and game fishes in that lake. The nature of some of them is apparent if not quite evident, but there are unknown factors which must be ascertained before the problem of how to rehabilitate the lake or maintain the present stock in it can be solved. Lake Champlain is a large body of water which, if properly regulated, might afford valuable fisheries for all time. The States of New York and Vermont control the greatest extent of water, although a comparatively small but important portion comes under the jurisdiction of Canada. It would seem that the lake affords such important fisheries possibilities that it demands international and interstate cooperation in an investigation, the results of which would provide basic knowledge for the joint establishment of adequate fish cultural procedures and rational effort directed toward the development and regulation of these fisheries.

RETROSPECT AND REFLECTIONS

The foregoing discussions embody only a small part of the evidence which shows that, from early times to the present, most of the efforts to restore and maintain the fisheries have been injudicious. But it would seem that enough evidence in that direction has been presented to afford food for thought, and to indicate that revised, if not to say reformed, restorative and constructive measures must be adopted, if the fishery resources are to be preserved for future generations. This discussion has pertained mainly to the "game fishes," for the reason that the State has given its principal attention to those species, but enough has been said to show that it is impossible to disregard the other kinds of fish. The game fish form only a part of the whole, and regulations pertaining to game fish involve correlated regulations pertaining to all other associated fishes. Again, regulations pertaining to the whole, or to the perpetuity of any important part of the whole, can be constructively effective only when based upon exact knowledge. Exact knowledge is available only through intensive and prolonged study of all conditions pertaining to the objects of regulation.

It has been repeatedly asserted that such studies have been too scattered, too fragmentary, or too incomplete to afford the necessary foundation for rational procedures and regulations. There is primary need for a sustained, constructive policy toward investigations of the fishery resources. Perhaps one reason for the unsatisfactory condition is that the fishery interests are so diverse, as some of them are located on international boundaries, some on State boundaries, and still others involve both international and State interests. That is to say, one body of water may border on several states and Canada, as for instance Lake Champlain. As a rule only the smaller bodies of water are wholly within the borders of any one state.

It is true that there have been international fisheries commissions,
and interstate conferences concerning regulation of boundary waters, but none concerning the possibility of establishing a foundation for intelligent regulation through biological and ecological investigations. Now and then the Federal government of the United States and the Dominion government of Canada have made independent sporadic observations, of one kind or another, and it may be said to Canada's credit, that she has been more persistent and consistent in that direction than has the United States government. Occasionally, too, a state, either in connection with the Federal government or alone, has made a beginning in the desired direction, but while the investigations pertaining to certain problems never have been concluded, they never have been even approximately completed.

As concerns the State of New York, the foregoing brief review of the "surveys" and "investigations" of its streams and lakes, reveals that they have been few in number, of limited geographical extent, and likewise limited in results immediately applicable to policies or procedures of fish conservation. The reason is that although special subjects, in one or another body of water have been quite thoroughly studied, others have received little or no attention, or else studies of one kind have been made in one body of water and those of another kind have been made in another, but in most instances the correlation of the results has not been possible. In fact no biological survey of any body of water that has been made in the State can be said to be complete in itself. Each may afford data that in a general way may be correlated with those of another, but few, if any, positive conclusions of definite practical application to any one body of water can be drawn from disconnected and temporary studies. Therefore, a definite, permanent and sustained policy of investigation is the price requisite for success.

It would be a serious oversight to conclude this discussion of the fish cultural investigations in this State without pointing out the remarkable situation with regard to the Hudson River. Here is our largest river, discovered over 300 years ago, and a stream without question of considerable capacity for producing inland fish in its upper portion. Aside from the intensive studies of the pollution of its lower section, what is known of the detailed biological conditions and of the fishery problems of this stream? In spite of the numerous educational and scientific institutions scattered along its course, and the great museums within sight of it, this stream remains to this day, so far as the fundamentals of its fishery needs are concerned, a veritable wilderness, as uncharted and unexplored as central Africa or Siberia. This is indeed a strange situation.

When the people of this State awaken to the anomaly of the situation and begin their serious study of this stream, they will have to turn for guidance to the Central West, where the Illinois River has now been seriously studied for a generation from the standpoint of its biology and its fisheries by Forbes and his associates, Kofoid, Richardson, and others. The results of their investigations form the most extensive body of data on the biology of any stream in America and indicate what should be done for the Hudson.
(Cf. Forbes, '10, '11, '11a, '13; Forbes and Richardson, '13 and '19; and Richardson, '21.)

However, under present conditions it is not practicable for any states, or any institutions, to make an intensive biological and physiological survey of every body of water, large or small, within a state, or in an extensive territory, within a limited time, or even in a long time, as it would require a larger force of specialists than is available, even if the necessary funds were available.

Outside of the United States Bureau of Fisheries, and to a considerable extent within it, scientists connected with institutions of learning have been practically the main dependence of the states for investigations of waters and fisheries. The scientific personnel of the United States Bureau of Fisheries has been and still is too limited in number, and the calls upon it too many, to permit of their general availability for investigations of sufficient duration to positively solve comprehensive problems.

College professors have rendered excellent service during summer vacations in collecting facts pertaining to lake and stream conditions. In fact the bulk of such knowledge, in recent years, has been obtained by them, and often without pecuniary compensation. The summer months, however, do not afford all the facts necessary for securing positive results upon which to base recommendations concerning fish and fisheries policies and procedures. Besides, their time for adequately analyzing the facts in hand is limited because of their college duties. It is such considerations which led Baker to suggest ('16, p. 316) permanent biological investigations on Oneida Lake. So perhaps in some cases in order to satisfy the demands for results by those who do not understand that a brief investigation cannot fill the requirements, the investigators may make hasty recommendations, if they venture to make any at all. Too often such recommendations, although based upon admittedly incomplete studies, are often accepted as final by officials and the public, when they are only preliminary and provisional. To repeat, partial investigations are made here and there every year; sometimes of one species, one problem, or one environment at a time, but they are incomplete and are never completed. Possibly no one makes further study of the subjects, either singly or in combination, for many years. It is well to emphasize here that there always will be problems, and investigations should never cease, because new situations and conditions are constantly arising. The investigations must be as continuous as the fishing.

Yet it is true, that every investigation, however incomplete it may be, adds to the stock of accumulated facts, inferences and principles; but if recommendations are based upon conjectures, the tendency is for subsequent fish cultural procedure to be as uncertain as before.

In the case of the streams of Oneida County, of which it is stated there are approximately 2,000 miles, all were investigated during the one season. Such hurried and partial examinations are manifestly inadequate, but the value of the work is considerable, if it does not stop there. Usually it does stop with the preliminary
observations, for often those in control of the funds can see no advantage to be gained by further work along such lines, especially if the report upon the "survey" injudiciously claims that it was "thorough enough for all practical purposes."

At a convention of the National Association of Fish Commissioners, John W. Titcomb, then State Fish Culturist of New York, said (Titcomb, '17): "It becomes apparent that in order to obtain the best results, a permanent policy must be established with regard to each stream, pond or lake which is to receive attention. In other words, the Commissioners of the different states should have a survey made of all the waters under their jurisdiction which are to receive any attention in the way of restocking. The results of the survey should be published in such a way that the successors of those who established the policy may have something to guide them in their efforts with reference to the same waters."

To this recommendation it may be added that to that end the Conservation Commission, or State Fish and Game Department, of each State should cooperate with a permanent and financially well-supported department or departments for the investigation of wild life, and one upon which it may depend. These administrative departments of the State governments have not, in the past, been able to furnish the facilities, in laboratories, libraries, or experiment stations, or the maintenance of the scientific staff, or an atmosphere favorable to prolonged scientific study of these wild life problems. It is probably only at special research stations, and at colleges and universities, that we can expect the most of such work to be conducted, where there is an atmosphere favorable for research and education, rather than that of administration. In New York State, the Roosevelt Wild Life Forest Experiment Station has been authorized by the State to perform just such functions, and it only needs adequate support to execute the kind of investigations that have been outlined in this paper for public waters, and such as it has already been conducting for several years in various parts of the State in the forest waters.

As concerns game fishes the purpose of such investigations should be to make as exhaustive a study of the lakes and streams as possible, which may be taken as representative of the various conditions generally obtaining in different sections of the State, and as heretofore, making use of such outside scientific help as may be available. By this means a definite policy could be more quickly and economically formulated and carried out than by present methods, of which the practical results lie far in the future. In fact they may lie so far in the future, that there will be no opportunity for practical application, in that the game fish will have joined the passenger pigeon in the "happy hunting grounds." This may appear like the fears of a calamitist, but one does not have to go far, and open his eyes very wide, to see what the present conditions are. If he considers them in relation to the expenditure of effort and money during the past 40 or 50 years, and if he has any interests beyond those of his own immediate selfish ends, he will
realize that if the downward trend continues at the same rate for even a few years longer, there is just cause for real alarm.

It cannot be expected that all planting shall cease until thorough investigations are made. But there should be a certain amount of judgment exercised and that judgment should be based upon examination of the waters to be stocked.

And for the sake of emphasis, it again may be said, in the words of Evermann and Clark ('20): "No stream or lake should be stocked with fish until it has been carefully studied by a competent biologist and found to possess the conditions or factors of favorable environment for the fish which it is proposed to introduce. Fish culturists should adopt this principle and adhere to it as an invariable policy. The rule of thumb, cut-and-try method so uniformly followed has brought no credit to fish culture in America."

It should be unnecessary to enlarge upon the last two paragraphs. The moral is: Know your lakes and streams; likewise know your fish; correlate the two and act accordingly. You cannot know the lake or stream without a thorough biological or ecological investigation; you cannot know the fish without a thorough study of its life history and habits, and you can no longer have fish without paying the price, in intelligence and funds, necessary to produce them.

SUMMARY AND CONCLUSIONS

1. The original fish resources of America and of New York State were not surpassed in variety or in kinds of food and game fish by any other continent or any State in the Union.
2. The primeval fish resources of America were bountiful; but these resources, like those of the game and forests, have been ruthlessly wasted and destroyed.
3. With the decline of this resource there was a period of reckless and random efforts to introduce foreign species, which were planted broadcast through the country in all sorts of conditions, to the detriment of all fisheries.
4. The proper evaluation of the native resources is just beginning to be appreciated, but no adequate Federal or State policies have been deliberately formulated and practiced. There is only a slight awakening to the need of such a constructive program.
5. The formulation of constructive policies involves detailed, comprehensive, scientific studies of this resource, such as have already been most successfully conducted at research or educational institutions, rather than in connection with administrative departments of the various states.
6. Because of the instability of political management of the fishery resources the conservation of fishes should be as free as possible from political interference.
7. Too often fish hatcheries, as commonly conducted, have depleted the local stock of breeding fishes in their immediate vicinity, in order to stock other more remote waters. As the customary planting methods are so frequently unsatisfactory this waste has tended to spread depletion radially from the hatcheries.
8. To maintain the breeding stock of fishes for the hatcheries and even to insure the existence of some species, it has already become imperative that *fish preserves*, like game sanctuaries, should be established at critical localities, as both State and Federal preserves.

9. Similarly, to conserve the breeding stock, the investigation of *post-hatchery problems of fish culture* must be enlarged and perfected, and be based on adequate field surveys.

10. To supplement proper planting a campaign of education among all organizations and individuals who plant fish will be necessary to prevent waste, or the gains made by improved methods will be diminished.

11. The problems demanding investigation are too complex and difficult to expect immediate solution all along the line. A sufficient technical staff should be available to permit part of it to be devoted to the continuous survey of the waters, and to problems involving more immediate attention, and the remainder of the staff to be devoted to other important problems, which require much more time for solution.

12. The public should be made fully aware of the magnitude of the difficulties involved in an investigative program for fish, so that they will come to realize that to maintain this resource there must be a continuous, permanent program, one which can never be completed so long as the resource lasts, and so long as conditions change which influence the fish. Investigations must be as constant as taxes.

13. From the standpoint of the general public, the public waters seem destined to soon become the last, and almost only accessible angling and fishing waters. The most accessible of these will be in the State forests and State parks, on the non-agricultural lands of the State. For this reason the systems or policies of management will be, in the main, those governing forest lands, and they should be so organized that there will be harmonious, consistent management for forests, fish and game, such as can best be established under a unified conservation commission.

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CURRENT STATION NOTES

CONSERVATION VERSUS EXTERMINATION.

The present number of the Bulletin is devoted exclusively to a discussion of the broad principles of the conservation of fish in our inland public waters. This subject has not been similarly treated previously, and Dr. W. C. Kendall’s long experience in these matters, while an official in the U. S. Bureau of Fisheries, gives his conclusions and opinions great weight. It is evident that in these matters we have been drifting, and have been whirling about in eddies instead of advancing in the main stream. As a result of this method a vast amount of human effort, labor and funds has been wasted. Many times have the effort and funds been lost that, under proper management, would have put the whole problem of our inland waters upon a thoroughly sound basis. The need of a broad perspective, such as can only be secured by scanning the whole field, has not been sufficiently realized. Even to many of the leaders in conservation, the views here expressed by Dr. Kendall will come as a great surprise and they should stimulate serious thought in the minds of many people.

With increasing population, and a more intensive use and abuse of our inland waters, the situation becomes constantly more complex and serious. The drainage of lakes, ponds and swamps, the contamination of inland waters by sewage and industrial refuse, the damming and otherwise obstructing of streams, have the same general unfavorable tendency; and finally by overfishing and defective and inefficient fish culture, the same tendencies are emphasized. All these conditions seriously interfere with maintaining the fisheries, and this has furnished the basis for concern. Of course, some of these changes are inevitable, with the industrialization of the country; but that is often only the excuse, and not the cause, for some of the gross blunders that have been made. We are now reaching the point where the public has begun to see the seriousness of the situation, and is beginning to take measures to ward off the threatening consequences. Constructive measures will have to be developed by increasing scientific investigations of fishery problems, in order to have a substantial basis of fact for practical conservation measures. Furthermore, anglers, fishermen, sportsmen and conservationists of all kinds, must be educated to the realization that conservation must be put into the hands of trained men, and must be freed, as much as is humanly possible, from political interference of all kinds. There seems to be a growing belief today that the greatest and most sinister influence affecting wild life, if any one can be singled out, is “politics.” The most hopeful remedy for dealing with such a problem is by giving the public reliable information, rather than the usual too abundant “propaganda,” and by elevating the standard of practical ideals in both conservation and in politics.
COOPERATION WITH UNITED STATES BUREAU OF FISHERIES

The Roosevelt Station has consistently endeavored to cooperate with other agencies engaged in wild life research. This has been the continuation of a policy adopted by the College in 1915 when it began the investigation of the fishery problems of Oneida Lake. In 1917 a beginning was made, with the United States Bureau of Fisheries, on a study of the fish parasites in that lake. This cooperation was made possible, to an important degree, by the broad-minded policy and active interest of Dr. Robert E. Coker, at that time in charge of the Division of Scientific Inquiry of the Bureau, and now at the University of North Carolina at Chapel Hill. It resulted in Dr. H. S. Pratt's paper on "Parasites of Fresh-Water Fishes" (U. S. Bur. Fisheries Econ. Cir. No. 42, pp. 1-8, 1919), and his "Preliminary Report on the Parasitic Worms of Oneida Lake, New York," and Dr. H. J. Van Cleave's "Acanthocephala from the Fishes of Oneida Lake, New York," both published in a preceding number of this Bulletin. While the Roosevelt Station was conducting investigations in the Palisades Interstate Park, on the Hudson River, in cooperation with its Commissioners, the Bureau of Fisheries again cooperated and the resultant publications were two papers by Dr. J. Percy Moore, one on the "Use of Fishes for Control of Mosquitoes in Northern Fresh Waters of the United States" (U. S. Bur. Fisheries, Ann. Report for 1922, Appendix, pp. 1-60. Doc. No. 923, 1922), and the other on "The Control of Blood-sucking Leeches, with an Account of the Leeches of Palisades Interstate Park," also published in an earlier number of this Bulletin. Still another result of this work has already appeared as "A Preliminary Report on a Fish Cultural Policy for the Palisades Interstate Park," by Charles C. Adams, T. L. Hankinson and W. C. Kendall (Trans. Amer. Fisheries Soc., Vol. 48, pp. 193-204, 1919). In this particular study, Dr. W. C. Kendall represented the Bureau of Fisheries. It is anticipated that similar cooperation will be continued in the future.

A NOTABLE GIFT TO THE STATION

Early in June, 1923, the Roosevelt Station received a valuable gift in the form of an exhibit, showing in fourteen stages the preparation of Hudson seal or seal-dyed muskrat, from the raw skin as received from the trappers, to the fully dyed fur. This exhibit is enclosed in a polished mahogany case twenty feet long, with plate glass front, and with electrical illumination. The whole exhibit is beautifully executed, and is both very attractive and instructive. This gift was made by A. Hollander & Son, of Newark, New Jersey, the leading dyers of this fur, and through the friendly services of Mr. Max Herskovitz of Alfred Herskovitz & Son, New York City. The gift is greatly appreciated because, from the inception of the Roosevelt Station, plans for the study of fur bearing animals have been included in its program, and such an exhibit is a very valuable addition to its equipment. New York City, is
today the leading center of the fur industry in the world, but unfortunately we have comparatively few adequate statistics on this subject. A recent rough estimate of the annual wholesale value of the manufactured furs in the United States gives it as approximately $200,000,000.00 to $250,000,000.00, and the value of materials entering into their manufacture is practically one-half of that amount. These figures show the great economic importance of this industry. The muskrat industry is considered our most important fur bearing animal. In the fur industry the status of the muskrat is at any time considered a fair index to the condition of the business, just as pig-iron is taken as a barometer of the steel industry. An estimate was made in 1920 showing that in New York City the annual business involved in handling muskrat fur is in excess of $200,000,000.00. During the year 1922 over 9,000,000 muskrat skins alone were dressed in that vicinity and of these over 8,000,000 were dyed there.

**THE DECLINE OF FUR BEARING ANIMALS**

Speaking broadly, many of the points made by Dr. Kendall in discussing fish, apply also to game and fur bearing animals. The same general principles which serve as a basis for the remedies suggested apply to wild life as a whole.

With the settlement of the country there has been, in general, a great decline in fur bearing animals, and at the same time there has been a greatly increased demand for furs. There have been many causes for this decline, including not only the trapping of furs and hunting, but as well the cultivation of the land, drainage, destruction of forests, rodent poisoning campaigns, and the destruction of predatory stock-killing animals and "game vermin." All have taken their toll until the future of this resource has become the cause of serious concern, particularly among the naturalists, and more recently among the broader minded of the men in the fur industry who are looking forward toward the permanence of their own industry, and who realize that a sustained annual yield of raw fur is the very foundation of their business. The situation in the industry reminds one of the old saying that: "We never miss the water 'til the well runs dry." Naturalists have made the mistake of not warning the public more fully of the true drift of events, and the fur industry has not in the past been accustomed to look to naturalists for help in solving their scientific problems. The situation has now become serious and the leaders in the industry are beginning to realize that scientific study of the life history, habits, and methods of propagation of fur bearing animals is not incidental but essential to the present and future welfare and the very existence of the business. One of the immediate problems now gaining recognition is that it is becoming more important to spend hundreds of thousands of dollars upon scientific studies and educational campaigns for increasing *fur production* than to spend a similar amount on advertising or other activities which are concerned solely with consumption. A new situation has arisen and it must be solved by new methods.
INCREASING FUR BEARING ANIMALS IN NEW YORK STATE

During the summer of 1923, Dr. Charles E. Johnson, Roosevelt Fur Naturalist, who made the Adirondack beaver study for the Station, devoted his time to field studies for the determination of the condition of the muskrat in Western New York. Secondarily, attention was given to the skunk and the raccoon. He began a comprehensive study of these animals, with a view toward increasing our knowledge of their natural history and breeding habits, and to methods of increasing their numbers on a large scale. The herbivorous habits of the muskrat and its rapid rate of reproduction indicate it to be the sort of animal adapted to large scale production, and a means of utilizing non-agricultural swamp lands, otherwise relatively non-productive, making them economically comparable to intensively cultivated farm lands.
THE ROOSEVELT WILD LIFE MEMORIAL

As a State Memorial

The State of New York is the trustee of this wild life Memorial to Theodore Roosevelt. The New York State College of Forestry at Syracuse is a State institution supported solely by State funds, and the Roosevelt Wild Life Forest Experiment Station is a part of this institution. The Trustees are State officials. A legislative mandate instructed them as follows:

"To establish and conduct an experimental station to be known as 'Roosevelt Wild Life Forest Experiment Station,' in which there shall be maintained records of the results of the experiments and investigations made and research work accomplished; also a library of works, publications, papers and data having to do with wild life, together with means for practical illustration and demonstration, which library shall, at all reasonable hours, be open to the public." [Laws of New York, chapter 536. Became a law May 10, 1919.]

As a General Memorial

While this Memorial Station was founded by New York State, its functions are not limited solely to the State. The Trustees are further authorized to cooperate with other agencies, so that the work is by no means limited to the boundaries of the State or by State funds. Provision for this has been made by the law as follows:

"To enter into any contract necessary or appropriate for carrying out any of the purposes or objects of the College, including such as shall involve cooperation with any person, corporation or association or any department of the government of the State of New York or of the United States in laboratory, experimental, investigative or research work, and the acceptance from such person, corporation, association, or department of the State or Federal government of gifts or contributions of money, expert service, labor, materials, apparatus, appliances or other property in connection therewith." [Laws of New York, chapter 42. Became a law March 7, 1918.]

By these laws the Empire State has made provision to conduct forest wild life research upon a comprehensive basis, and on a plan as broad as that approved by Theodore Roosevelt himself.

Form of Bequest to the Roosevelt Wild Life Memorial

I hereby give and bequeath to the Roosevelt Wild Life Forest Experiment Station of The New York State College of Forestry at Syracuse, for wild life research, library, and for publication, the sum of .........., or the following books, lands, etc.

1. The Control of Blood-sucking Leeches, with an Account of the Leeches of Palisades Interstate Park...........Dr. J. Percy Moore.
3. Acanthocephala from the Fishes of Oneida Lake, New York...........Dr. Harley J. Van Cleave.
4. Current Station Notes.........................The Director and Editor.


1. Ecology of the Plankton Algae in the Palisades Interstate Park, Including the Relation of Control Methods to Fish Culture.................Dr. Gilbert M. Smith.


1. The Status of Fish Culture in Our Inland Public Waters, and the Role of Investigation in the Maintenance of Fish Resources......Dr. William C. Kendall.
2. Current Station Notes.........................The Director and Editor.