March 23, 1937

K.O.Wilson

FISH CULTURE

F 407

Senior thesis

FISH CULTURE

The original fish resources of the inland waters of North America were among the richest in the world. This was a wonderful resource which comprised not only a great variety of species but also vast numbers of individuals of the most desirable kinds of fish. Our fish resources have not been adequately appreciated by the public, even during the great wave of agitation led by Theodore Roosevelt, because through 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 following brief 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 pertinent conservation problems. The emphasis on surveys and intensive investigation, it is hoped, will serve to discourage the present 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 will depend largely upon which of these policies is emphasized from now on.

The purpose of this thesis is to present the broad outlines of some of the major problems involved in the fish cultural management of the public waters as they appear at the present time, and to present some of the probable reliefs to these problems. The present trend of events seems

to point clearly to the conclusion that the main stronghold for fish in the future lies in the waters of non-agricultural and public lands. For this reason an increasingly closer relationship between the problems of wildlife and other phases of forestry may be anticipated.

Up until some fifty years ago practically all of the inland streams and lakes in the North American continent were abundantly stocked with native fish. Many old timers still tell tall stories of the super-abundance of fish which inhabited the inland waters. Although many of these stories are by this time greatly exaggerated, they are still based upon actual facts, and it has become an accepted fact that the inland waters at one time contained many times the numbers of fish which now inhabit them. According to traditions, inhabitants in the neighborhood of waters which teemed with fish captured them by the wholesale. The fish were primarily taken for food, but those which were not disposed of otherwise were frequently fed to the hogs or utilized 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 and needlessly slaughtered.

Another factor which resulted in the ultimate depletion of fish in the streams and lakes was the erection of dams in the streams with no provision made for the ascent of the fish to the spawning grounds on the upper reaches of the streams. Suitable spawning grounds below sawmill dams were

soon so badly choked with sawdust and waste as to shut the fish out of their natural breeding places, and unless other suitable places were found, the fish died out. The destruction of forests and the drainage of lakes, ponds and swamps have all had a most unfavorable influence upon the fish.

At first sportsman-anglers were few and as a rule sought only game fish of high repute, but in recent years practically any fish that will take a baited hook is in some locality regarded as a game fish.

In some sections declines in the number of fish became quite noticeable and various measures for the protection of the fish and the restoration of the fisheries were enacted by state legislatures. At first legislative acts concerned food fishes only, with little or no consideration of the anglers interests; but after a while two interests had to be recognized, that of the commercial fisherman, now being of paramount importance, 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. The locality of the fishes finally became the chief factor in determining to which class the fish should belong. So it turned out that fishes which in one locality became classed as being predominantly of commercial importance, in other places were classed as game fishes only and their sale in markets was restricted or absolutely forbidden.

The unsatisfactory results of protective and restorative fishery legislation were so marked that the introduction of fish culture or artificial propagation was hailed with enthusiasm. To those persons most concerned, the State Commissioners, fishermen and anglers, artificial propagation became the outlet which was to open the gates through which the rivers, lakes and streams were to be restocked.

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, Department of Commerce.

The decline of the sea and river fisheries was the first object of inquiry by the Commission. Subsequently, the propagation of game fish for inland waters constituted a considerable part of the functions of the Commission and still forms one of the most important divisions of the bureau. Federal fish hatcheries and fish cultural stations of one kind and another have been established in almost every state of the union, and the states have their own legislation and hatcheries, sometimes as many as a dozen or more in one state. Millions of fish eggs are hatched yearly and the young fish are distributed far and wide in the waters of this country. Thousands of dollars have been

expended in these operations, the results of which operations being reflected by the present conditions.

Efforts made to meet the rising demand for increased fishing facilities were made without knowledge or consideration of the existing conditions of the waters or the possible effects of the introduction upon the native or on the introduced fish. In this respect fish cultural distribution was of the nature of a venture rather than a rational procedure or experiment. The trouble lay in not realizing that new factors were likely to disturb natural conditions, and that the way to regulate conditions already disturbed was to restore as nearly as possible the original or normal conditions.

Indiscriminate fish planting in the past and even today is the cause of much of the unsatisfactory present condition. 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 small ponds, near and far, without regard to the habits or physiological requirements of the fish, and very often to the detriment of the fish native to the waters into which the transfers were made.

The key to intelligent and satisfactory fish cultural distribution lies in the application of facts determined from an exhaustive study of the food and environmental habits of the various species of fishes. Succeeding this preliminary survey should come a more careful study designed to ultimately increase the supply of game fish by (1) a study of the growth,

food, spawning, and habits of the different species of fish inhabiting various waters and, (2) the determination of the species best adapted to certain classes of waters, by an experimental study of type waters.

At the present time, previous to the stocking of virgin lakes on the west slope of the Cascades, a preliminary survey is made of the lake in reference to the possibility of successful stocking, covering the following points:

(1) Source, length, width and depth of water.

(2) Character of the bottom.

(3) Rate of flow, if any.

(4) Color and transparency of the water.

(5) Vegetation in and along the lake shore and shade provided.

(6) Spawning possibilities.

(7) Necessity of wier construction.

(8) Character of the surrounding country; that is whether the lake is likely to be subjected to extremely high or low waters, or the inflow of a large amount of sediment from the surrounding country.

(9) Water temperatures from source to mouth .

(10) Obstructions to fish migration.

(11) Evidences of pollution with their sources and effects.

(12) The quantity and variety of food organisms for fish.

(13) Kinds and condition of fish already present, if any.

(14) In lakes in which fish are already present, a few fish are taken and preserved in formaldehyde for future laboratory investigation for the possibility of disease or worm infestation.

(15) Table

(15) Natural enemies of the fish, such as fish eating and egg destroying insects and mammals as well as birds.
(16) Samples of the bottom food taken by means of a miniature dredge, and the different types of food are preserved in bottles for future study and identification.
(17) Samples of food suspended in the water taken by means of a drag screen, and the types of food preserved.

From the results of such an exhaustive survey as outlined above, an accurate estimate may be made as to the species and amount of fish which the lake will be capable of holding and maintaining over an extended period of time.

In high mountain lakes where cold temperatures occur, the depth of the water is of primary importance. For lakes in the Cascade range a minimum depth of 10' is considered adequate to insure the lake against freezing solidly thereby robbing the fish of water.

The character of the bottom is in direct relationship with the food supply and the spawning possibilities. West Coast game fish require coarse sand or gravel bars in which to spawn, preferably in running water, although they have been known to spawn successfully in quiet lakes if gravel is present and the water is reasonably fresh. Spawning facilities are at their best where there is a fresh water inlet or inlets to the lake up which the fish may migrate during spawning season.

In the case of certain species such as the landlocked steelhead salmon, which become rainbow trout when

landlocked, it is necessary to build a wier at the outlet of the lake in order to prevent the fish from instinctively attempting to return to the sea.

Surface and bottom water temperatures ordinarily vary from five to twenty degrees in range. The temperature of the water has a direct bearing upon the species of fish to be planted. Certain species such as the Eastern Brook trout can thrive in much warmer waters than other species. The native Cut-throat trout require a temperature of not more than fifty two degrees F to insure satisfactory conditions.

If the lake under consideration for restocking is already stocked with fish it is necessary to determine the species of fish which now inhabit the lake. Certain species such as the Dolly Varden, Loch Leven, and Eastern Brook trout have carnivorous habits and are particularly fond of young fish of the fingerling size. For this reason the species already present is important to know before restocking.

The so-called natural enemies of fish are many and various, almost all zoological as well as some botanical classes are represented. Bacterial, fungous, plasmodial and parasitic diseases destroy them individually and epidemically. Non-parasitic as well as parasitic worms and crustaceans and even some insects are not infrequently fatal. Among the vertebrates certain fishes, reptiles birds and mammals can be mentioned. Of these the predacious fishes are generally regarded as being the most serious. These so-called enemies are nature's method of maintaining a balance in nature, and it is only when normal conditions are

disturbed that those enemies of any fish become generally harmful. On the whole, man has been the most destructive enemy to fish.

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 consistent labor and care to rear, are lost primarily through improper handling in the planting operation. In many cases the lack of special knowledge and experience on the part of those who transport the cans to the streams and lakes and do the actual planting results in great loss.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 the young fish are planted.

Opinions differ concerning the age at which young fish should be planted. Some fish culturists advocate fry, others advocate fingerlings, and still others older fish. Each exponent supports his views with valid evidence. Exponents of fry planting have demonstrated beyond question that fry planting can be made effective in all of the different states of the Union. Another argument advanced in favor of fry planting is that of the attendant difficulties and the expense of raising and handling older fish, and that fry can be transported and distributed in greater numbers than is possible with fingerlings or older fish.However, in favor of older fish than fry, it has been quite

generally admitted that the older a fish is the better able it is to take care of itself. The chief argument against the 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 had sufficient training to give the planting the attention it requires. The Federal Commission of Fisheries is accordingly devoting much attention to systematic educational work among the applicants with a view to better planting, and in the meanwhile is continuing its efforts to increase the output of fingerlings.

The object of planting the fish is to supplement the native supply or to make up for the deficiency in natural production. In this connection it should be borne in mind that from time to 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 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 fish in the spawning beds.

The season of the year when the young fish should be planted has been a much discussed subject, and there has been a more or less diversity of practice. The season would seem to depend somewhat upon the kind of fish, however it would seem logical to plant the fish approximately at the

time they are known to appear naturally in those places.

Mortality table for the various sizes of fish planted:

Size in inches--	1	2	3	4	6
Mortality--	95%	65%	40%	20%	0%

Note: The above data was taken from a publication in " The Progressive Fish Culturist", written by A.C.Taft, Ass't. aquatic biologist U.S. Bureau of Fisheries.

PLans for stocking should be made during the driest part of the preceding season. Only streams and lakes or parts of them which have not then dried up or become stagnant should be considered in the plans for future planting. Every detail regarding the adaptibility of the stream or lake regarding the desired fish should be carefully considered. Foresight in this direction will save many fish that otherwise would be lost.

The two chief requirements of young fish are protection and food. They demand protection from predacious enemies, freshets, droughts and disease. In general, for stream inhabiting species, the headwaters constitute the most advantageous planting points. Here the larger fish are not apt to be present to prey upon the fry. Freshets are not so strongly felt here, and are less likely to wash the small fish downstream. Also the chances of pollution are much less. Care must be taken, on the other hand, not to plant fish in streams or headwaters which may dry up in times of drought. For the planting 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 waters inhabited by the adults.

The cans containing these young fry should be accompanied from the hatcheries by a messenger to care for them during the journey. The water in the cans must be kept constantly aerated, in order that the fish will not suffocate from lack of oxygen. Unless special apparatus is provided, this is done by hand, the water being dipped up from the top of the can and allowed to fall back from a height, or a frequent vigorous shaking of the cans will produce the same result. The water must also be kept cool with the use of ice, if necessary. Under no circumstances must the fry or fingerlings be allowed to stand for periods of over one half hour without attention. It is necessary to take them directly to their destination and plant them immediately.

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 in vain, for a difference of only a very few degrees between the water in the cans and the

water in the lake or stream to be planted will prove fatal to young fish. However small the variation may be, the temperatures must be equalized by dipping water from the cans into the stream and from the stream or lake into the cans a little at a time. Another method is to stand the cans in the water; however this procedure takes a much longer time. applying both methods at the same time would facilitate a rapid equalization of the temperature in the cans.

When the temperature is right, the cans may be emptied. The fish may be dipped out or carefully poured from the cans. In the latter case, the mouth of the can should be held no more than a few inches from the stream or lake so that the fry will not be jarred by the impact of the water. The fish should be spread out as much as possible. No more than 500 fingerlings or 2000 fry should be planted per mile in a small stream. The food supply will be in danger of exhaustion in overstocked waters.

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 streams and small 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 which inhabit the lower reaches of the stream. After attaining a suitable size, however, they will of their own accord seek the lower stream where food and water are more abundant. In most cases, materials for such dam construction may be found in or near the vicinity of the dam site. The structures need not be more than 12 or 15 inches in height. The tops of the dams should be made 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, when they are ascending the streams for spawning purposes in the fall.

A natural method of improving stream conditions is by the propagation of beaver colonies. The dams resulting from their efforts create the desired effect in providing food and shelter for the young fish.

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 or basins. The inlet of the streams and the outlet of the side pools should be screened to prevent the entrance of larger fish from the stream to prey on the small fry.

In restocking waters, having first ascertained to which kinds of fish the waters are suited and having stocked them accordingly, the main problem is then that of regulation,

conservation and the maintainance of a supply in coordination with the demand made upon it. To these ends for many years it was the common custom to close newly stocked waters for various periods of time for the purpose of giving the fish time in which to grow and establish themselves.

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 strongest ally of stocking is the protection of the young fish. Without stabilized protection the stocking will be of no avail. The game protective force is constantly on duty to help prevent illegal fishing in all its forms,and has accomplished results which places this organization 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 by the sentiment of the community to which it applies. Everyone interested in better fishing should foster the developement of a clean and sportsmanlike spirit regarding the observance of the fishing laws. Without such moral support and active cooperation on the part of th the sportsmen, the laws cannot be properly and effectively enforced and the sport of fishing will be on the decline.

Laws intended to protect fish should be based upon positive knowledge concerning the fish to be protected. Unless they are made in accordance with such knowledge, no

matter how rigidly they are enforced, they are very liable to fail in their object, and even result in harm to the fish for the protection of which the law was originally enacted.

It is generally conceded that fish should be protected during their breeding season. This is in direct conflict with the activities of most commercial fisheries, which can only make their large catches when the fish are on the way to the spawning grounds.

The problem of closing the waters to fishing either temporarily or permanently involves several considerations. The fact that a body of water will support a certain amount of organic life and no more is of major importance. A small stream or brook, for example, 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 fish depends in a great measure upon the quantity of its food supply. Investigations and ecological studies have not yet reached the point where we can correlate the available food supply with the exact or even the approximate number of fish that should be planted in a given area. It has usually been the custom to consider the size of the stream and merely guess at the number of fish that should be planted, in order that it may be adequately stocked.

In furthur consideration of the protection of the fish it may be said that although it is ~~not~~-impossible to control the number of anglers, it is quite possible to control the

activities of these anglers. Thus the present opened season for angling in the State of Oregon is a good example of one method of restricting the actions of the anglers. Laws have been passed restricting the methods of fishing for certain kinds of fish, such as the restriction for fly fishing only, laws making prohibitive the use of certain types of tackle and multiple hooks.

Although many of these laws and regulations have not proved satisfactory and many have been repealed, they still show that efforts are being made to improve present fishing conditions on the fish conservation program. Perhaps the most logical step in the protection of the fish supply would be one which runs parallel with our present game conservation program; that is in the establishment of natural sanctuaries for each species concerned. In other words a 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. It would be possible to so manage such an area or reservation that the future egg supply would be practically inexhaustible.

The foregoing discussion embodies only a small part of the evidence which was intended to show that from early times up until the present, most of the efforts to restore and maintain fisheries have been on the whole more or less unsuccessful. However, I believe enough evidence has been presented to indicate that revised and constructive measures must be adopted if the fish resources are to be preserved for future generations.

With the present agitation towards placing the control of fish resources in the National Forests under the Forest Service, it is hoped that the foregoing discussion will at least in a small way bring forth some of the major problems with which we, as potential future Foresters may be forced to handle , and upon which we may be forced to make decisions.

References used in compiling this thesis:

1- Roosevelt Wild Life Bulletin- volume 2
The Roosevelt Wild Life Forest Experiment Station
New York State College of Forestry.
2- Fish Planting in Public Waters- N.Y. State Conserv. Comm.
3- Annual report of the Division of Fisheries and Game, Mass.,for 1921
4- Extracts taken from a study of Oregon's Wild Life Resources, prepared by V.L. Sexton of the Oregon State Planning Board.
5- Bell, Frank T. - Proposals for the Solution of the Fishery Conservation Problem.
6- Keil, W.M.- Better Stocking Methods.
7- Rodd, J.A.- National Fresh Water Fish Cultural Policy.
8- Allen, G.W.- Conditioning Fish Before Planting.
9- Dahl, Knut- Stocking, Does it Pay?
10- Embody, George C.- Justification of the Planting of Large Fish.