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The point of emphasis upon fish cultural work has for a period of years been shifting from the hatchery to the natural environment. This evolution in viewpoint was bound to occur, for it has become increasingly clear that the hatching and planting of fish provide no general panacea for our fish cultural ills. We should consider, however, the hatchery procedure as an integral part in the whole fish cultural scheme of which an understanding of the prevailing conditions in natural habitats is also an integral part. The hatchery procedure has developed to a point where trout, for instance, can be hatched and reared to a young age quite successfully. On the other hand, our knowledge of the natural habitats in the Maritime provinces is still sketchy, and our endeavours to evaluate and to alter conditions in lake and stream in order that stocking may be more intelligently executed are still in the preliminary stages. Certain measures for improving stocking methods have been undertaken in the Maritime freshwaters, while others have been contemplated. It would seem opportune, therefore, to examine these measures and the manner in which they might be prosecuted.

This discussion does not consider the measures exhaustively, nor does it include all the possible procedures that might be undertaken for improving our stocking policies, but it does include accounts, incomplete as they may be, of those methods

that are considered most feasible and applicable at the present time for the Maritime waters. In the discussion, speckled trout are primarily considered.

1. STOCKING, CLOSURE AND ADEQUATE PATROL.

When the trout stock in a lake has been seriously reduced or depleted by angling, it often happens that undesirable fish secure the upper hand and dominate the habitat. A lake will support only a limited number of fish, and it must be considered that the waters are wild and not cultivated. Thus, when a lake is supporting a large number of trout predators and competitors, elimination of these undesirable fish is indicated. However, in many lakes and streams the predator action of fish does not seem to give the answer to failure of stocking, since such species are absent. Accordingly, over-fishing is the most apparent cause. Then, logically, stocking, closure and patrol of these waters is the procedure to follow. We cannot demonstrate the success or failure of such a procedure unless planned and properly carried out. Neither is a widespread application of the procedure justifiable until tests are made in one or two restricted areas.

With these considerations in view, a memorandum has been prepared, setting forth a scheme for stocking lakes with speckled trout in Charlotte county, New Brunswick. We quote from that memorandum:

"Primarily select a number of lakes which do not support a dominant predator population and which are reasonably

"close to each other. In this case we have selected the following eight lakes in Charlotte county: Welch, Gibson, Limeburner, Bonaparte, Navigation, Johnson, Kerr, Saint Patrick. Stock and close to angling two of these lakes in one year, two the second year, two the third year, and the remaining two the fourth year. In the fourth year open to angling the first two stocked, and likewise the other groups of two after there has been a lapse of three full years from the time they were stocked. In the fifth year again stock and close the first two lakes, and then the other groups in rotation. Thus, after the scheme is in operation, two lakes will always be open to angling in any one year, and six closed."

It is apparent that the prime prerequisite for the scheme is an adequate patrol to stop illegal fishing. If proper protective measures are not taken, then the stocking as outlines in the scheme would provide no advance over the policy now employed in many lakes.

In order to evaluate the results of stocking under the scheme a creel census is essential when the lakes are opened to fishing.

Funds are required to carry out the plan. In the test case it is considered that the necessary funds should be supplied by the Department of Fisheries. However, if the procedure is found feasible and productive of good results, and accordingly more extensively applied, then the angler

should be called upon to bear his share of the expenses. This could be accomplished, in part at least, by charging a rod license for angling in the controlled waters.

The scheme advocates two essential measures: (1) adequate patrol, and (2) a creel census to evaluate the results. These ideas are by no means new. Our present fish culture practices in the Maritimes attempt these measures to a degree, but in such a manner that no precise results can be secured. The scheme does not primarily require scientific investigation to be carried out, and the Department of Fisheries can directly apply it, but it does provide a basis for future scientific endeavour. In all probability the several lakes would show marked variations in the number of trout produced. Then scientific investigations should follow to determine the cause or causes for these variations. By this means, criteria as to what a lake of a certain character might be expected to produce can be secured. At present investigations are made of lakes with the view of determining whether they are suitable habitats for trout. It is known that trout require for best development certain conditions of temperature, oxygen content, etc., but how favourable these should be to justify the stocking of a lake is at present largely unknown. A large percentage of our lakes no doubt supported trout and would again if proper conditions were created, but the quantity of trout they would produce would vary widely, and many could be ruled out as poor producers, if sufficient data were at hand from investigated habitats to serve as a guide.

This scheme could be enlarged to include tests upon streams.

2. DESTRUCTION OF UNDESIRABLE FISH BY POISON

As a result of the depletion of the trout stock in many lakes, undesirable fish, which may be considered as inimical to successful stocking with young trout, have become dominant. Under such conditions, as indicated above, the destruction of these fish is indicated, and this can be most thoroughly accomplished in lakes of a small size by the use of fish poisons such as copper sulphate or Derris root (rotenone). Once the unwanted fish are destroyed and conditions are suitable for planting trout, then stocking with fry or young fingerlings can be carried out. By creating a habitat in which fry or young fingerling trout can be planted, we are most economically utilizing the hatchery product. We require the hatchery to produce the stock, but we are supplying a procedure which eliminates the necessity of rearing trout on artificial foods and under artificial conditions. Thus, this procedure accomplishes two objectives: (1) it provides a means of rehabilitating trout habitats and (2) it reduces the cost and loss of fish that occur in the hatchery as soon as attempts are made to raise them to a larger size.

To determine the efficacy of this procedure the following plan should be adopted in the experimental areas. Unless a plan is followed the end result is liable to be ambiguous, and not basic for further application of the method.

(1) Selection of a lake which is known to have produced trout, but in which the fish population is now controlled by trout

predators. The selection should be made by a scientific investigator, and some information upon the number of species contained in the lake should be secured.

(2) Observations upon the physical and biological conditions in the lake prior to the treatment in order that conditions arising after the poisoning can be properly evaluated.

(3) Destruction of the fish population.

(4) Estimation of the fish population as a guide to what the lake may be expected to produce in the future.

(5) Stocking with fry or young fingerlings as soon as conditions warrant.

(6) Closure of the lake to fishing.

(7) A second treatment of the lake with poison after the fish are a year or more of age to determine most accurately the results of the procedure, or, as an alternative, open the lake to angling, accompanied by a creel census, and then followed by a second treatment to determine the residual stock of fish.

The poisoning procedure has been started in four Nova Scotian lakes under the auspices of the Department of Fisheries. Jesse, Boar's Back, Tedford and Trefry's lakes have been treated with copper sulphate, Jesse in 1934, Boar's Back and Tedford in 1936, and Trefry's in 1938. Lake Jesse was stocked in 1936 and will be opened to fishing in 1939. Boar's Back and Tedford lakes were stocked in 1938. In Potter's lake, New Brunswick, the procedure is in progress under the auspices

of the Fisheries Research Board, and in this lake the procedure will be carried through according to the above plan. In the Nova Scotian Lakes, it seems improbable that the lakes will be treated a second time before angling is permitted. It cannot be too strongly urged, therefore, that a creel census be made from these lakes, followed by a second treatment. In the original scheme Hectanooga lake was selected as a control area for lake Jesse, in which the fish population was unmolested but in which fish were planted at the same time and at the same ratio as in Jesse. Thus any plan for Jesse should include Hectanooga.

Results according to the above plan will be secured from Potter's lake. If adequate results are obtained from the Nova Scotian lakes by a creel census and a second treatment with poison, then a variety of lakes will have been tested, and the possibilities of the procedure determined, thus providing a firm basis for a more extensive application of the method. The results from lake Jesse will not be clear-cut, since this lake received a second planting of trout and also a undetermined number of salmon. Further the outlet of this lake was not screened to prevent the downward migration of fish until 1938. If it should become a question that only one or two of the Nova Scotian lakes will receive a creel census and a second treatment with poison, then all effort should be made to determine the results from Tedford lake. (It is urged that all the lakes receive this treatment.) Tedford lake is given the first consideration because of the

ambiguity that will arise in the results from lake Jesse, because Boar's Back lake is fundamentally non-productive, and because in Trefry's lake the procedure has just been begun.

5. DESTRUCTION OF UNDESIRABLE FISH BY NETS AND TRAPS.

The poisoning method for eliminating undesirable fish is limited in its application. It would be impracticable to treat a lake several hundred acres in area and containing a correspondingly large volume of water, notwithstanding the fact that the predator fish problem may be just as acute in large lakes as in small. For these larger lakes the capture and removal of predators by nets and traps has been considered, and a certain amount of work of this nature has been started in the Maritimes. In 1937 one trap was placed in lake Annis and a considerable number of fish, principally white perch, were removed from the lake. In 1938, two or three traps of a similar character were erected in Milo lake, at Yarmouth. However, the Department of Fisheries, which inaugurated the work, realizes that adequate results in regard to the effectiveness of the method will be hard to obtain in these cases, since Milo lake is one of a chain of lakes, and since the work is now proceeding on no particular plan.

It is not possible to remove all the undesirable fish from a lake by nets and traps. Further, a more or less continued effort is necessary to keep a trout predator, such as white perch, under control. It may be possible to reduce the predator fish stock to a point where planting with trout might be accomplished successfully. Once a trout population is

established, the trout themselves might check the natural increase of predators, but, if angling is permitted and trout removed, then netting must be resumed to prevent any increase in the predator stock. We would consider that netting was only a temporary measure, or possibly permanent only so long as effective removal of predators is continued.

Since this method of predator control has been advocated as a fish cultural measure, and, in all probability, will continue to be advanced in the future, it is desirable to establish how effective it may be. It would be best to restrict operations to one lake at present, and there prosecute the method according to some definite plan. We propose the following tentative plan of operation.

(1) Select a lake which has provided good trout fishing in the past and may yet contain some trout, but in which there is now a large predator fish population.

(2) Inaugurate a creel census if the lake is still fished for trout.

(3) Carry out extensive netting, either by means of trap nets, gill-nets or seines.

(4) Mark and release all the fish captured during a preliminary period. Carry on this procedure until an estimation of the predator fish population can be made through a comparison of the number of unmarked to marked fish. For this purpose trap nets would be most suitable.

(5) Continue to capture fish until the predator stock is materially reduced, say to fifty per cent or more of the

estimated population.

(6) Plant the lake with trout, preferably with advanced fingerlings or yearlings. Tests could, of course, be made with various ages.

(7) Close the lake to fishing until these trout are at least three years of age.

(8) Open to angling and maintain a creel census.

(9) Continue the netting so that the predator stock is kept to a level at least fifty per cent below the estimated number the lake originally supported.

The experiment should be under scientific supervision, although the actual operations could be carried on by non-scientific men who were trained in the method. Two men would be required during the spring, summer and early fall of each year until the experiment was terminated.

It is suggested that Digdequash lake, Charlotte county, New Brunswick, would be a suitable area for the experiment. The lake is tributary to the Magaguadavic river, and covers several hundred acres. The lake has been noted for trout angling in the past and still provides some fishing. The catches have been steadily declining. The lake supports, among other fish, a large population of yellow perch. Supervision of the experiment could be made by the staff of the Atlantic Biological Station, although at present it could find only limited time to aid in the actual operations. It is suggested that at least six trap nets be erected, and supplementary work be carried on with gill-nets and seines.

4. FLOODED AREAS

By the erection of dams and the flooding of low-lying areas, habitats may be created in which there is a natural fertilizing of the waters through the decomposition of organic matter contained in the submerged vegetation, and in which trout may be reared from the fry stage in the presence of suitable foods and in the absence of predator fish. For most successful trout production certain conditions should be met. The flooded area should be sufficiently fertilized to produce an abundance of trout foods, but on the other hand have an adequate circulation of water through the area to prevent stagnation, with the accompanying high temperatures and low dissolved oxygen contents.

Four flooded areas have been investigated in the Maritime provinces: (1) Moose Pasture pond, Atlantic Biological Station; (2) Stephenson's pond, Loch Lomond (The dam was erected by the St. John branch of the New Brunswick Fish and Game Protective Association); (3) Wittenburg pond, Nova Scotia (This pond is maintained by the Department of Fisheries); (4) New Minas pond, Kentville, Nova Scotia (The dam was erected by the Kentville branch of the Nova Scotia Fish and Game Protective Association). In the case of the first three ponds mentioned a large amount of vegetation was submerged. Little water flows through the areas by mid-summer. The decomposition of submerged organic materials has caused low oxygen contents in summer. In regard these conditions the ponds in question may be regarded as rather extreme cases. Up to the present time poor results have been secured in

attempts at rearing trout. It might be expected that as the ponds aged and decomposition of the submerged vegetation decreased good trout habitats would be created. However, the amount of organic material was so large that apparently long periods are necessary before such conditions will prevail. In general, our observations indicate that it is not advisable to create ponds in areas similar to these.

At New Minas, Nova Scotia, the water submerged comparatively little vegetation and the pond was spring fed. Unfortunately the dam was destroyed by high waters before any worthwhile results were secured.

Other flooded areas have been reported in the Maritimes, but concerning these we have little information, and conditions before and after flooding have not been investigated.

At the present time, therefore, we have data upon only one type of pond, namely that in which large amounts of decomposable organic matter are present and there is poor circulation of water. If we judge the procedure upon these ponds, then only poor results can be indicated. Upon theoretical grounds and from sketchy information upon other flooded areas we are led to believe that the procedure has possibilities under certain conditions. A demonstration of the procedure is now needed in at least two additional types of flooded areas: (1) A pond in which much vegetation is flooded but through which there is a good flow of water throughout the summer; (2) a pond in which little vegetation is flooded and

through which little water circulates, particularly in summer. It is considered that in these types of flooded areas a most favourable balance would be secured between the desirable and undesirable factors.

To carry out further experiments upon the procedure, it would require the selection of sites, the selection to be based upon such knowledge as has been secured from Stephenson's pond, etc. It would require considerable expenditure of funds for the erection of dams. However, this initial expenditure would be a large part of the total required for the pond. Finally it would require the services of a man trained in aquatic work.

The value for fish culture of investigating flooded areas is the possibility of rearing trout from the fry stage to a size more suitable for planting purposes under conditions whereby natural rather than artificial foods are utilized. This would infer that little or no attention need be given the fish while growing. Circumstances being similar, the older the fish the better they are for planting, thus the fish reared in a flooded area might be used to advantage in any neighbouring waters. However, a very good purpose could be served by using the procedure in the rehabilitation of large lakes as trout waters. If flooded areas could be maintained tributary to the lake in which it is desirable to plant large fish, as would be the case with a large lake supporting many predators, the procedure would have its most direct application. This was the object, presumably, in creating Stephenson's pond.

The trout were to be directly released into Loch Lomond.

5. ARTIFICIAL FERTILIZING OF FRESHWATERS.

It is well established that the use of various organic and mineral fertilizers increases the productivity of freshwaters. As yet the demonstrations have been largely made in small bodies of water. Fertilizers have been widely employed in pond fish culture, for carp, black bass and fish of similar habits. There has been little work to demonstrate how well trout, which essentially are not pond fishes, can be produced in fertilized waters. Some tests have been made at the Atlantic Biological Station in which it has been shown that fair success can be attained in rearing trout during the summer months in small concrete ponds, fertilized with small amounts of herring meal. These experiments have progressed to the point where demonstrations on a larger scale are desirable in order to show the value of the procedure for fish culture. A pond, an acre or more in extent, in which the volume of water could be controlled and in which little natural fertilization would be taking place, is needed.

The value of demonstrating this procedure is, as was the case with the flooded area, that trout can be reared on natural foods in a habitat away from predatory fish without much attention. One advantage of this procedure over the flooded area is that the degree of fertilizing is more controllable, and excess decomposition effects can be avoided. It must, however, be realized that tests upon the procedure are only in the preliminary stages, and much work under scientific guidance isstill required before the method can

be applied as a general fish culture measure, or discarded as unsuitable for trout propagation.

Another phase of this procedure may be indicated. From our experiments upon rearing trout in fertilized water, it has been found that the amount of fertilizer that can be used is small. If much fertilizer is employed, the dissolved oxygen content is seriously depleted, not directly through the decomposition of the fertilizer, but indirectly through the algal production. Algal growth is stimulated and may be large as a result of fertilizing, but it is subject to marked fluctuations in quantity. At times the algae suddenly die off and this results in an oxygen depletion. However, trout foods, as Daphnia, apparently require less oxygen than trout, and moderately heavy fertilizing produces large numbers of these entomostracans, under conditions unsuitable for trout. Thus, the production of Daphnia and the use of them as an auxiliary food for young trout may prove of value, for it is argued that natural foods are very desirable as a supplement to the artificial diet employed in our hatcheries.

Since the fertilizing of small freshwaters definitely increases their productivity, the question arises as to whether we can increase the production in a lake by the same means. Recent work in Wisconsin and our experience at Gibson lake indicate that favourable results may be secured. Many problems are involved however, and additional demonstrations of the procedure are needed. An experiment of this nature should be carried out according to the following general plan.

(1) Select a lake, preferably one in which the natural productivity is apparently poor, and in which there appear no adverse characters inherent in the waters themselves, such as high acidity, etc., to account for the low productivity. In the last few summaries upon the year's work, we have indicated Miller pond, Grand Manan, as a possible site for carrying on a fertilizing experiment, for, as far as we could determine, the productivity of the lake is low, but physical and chemical conditions of the waters do not seem adverse, except possibly a scarcity of nutrient materials.

(2) Estimate the productivity of the lake for one or two years prior to the fertilizing. By productivity is inferred the amount of nutrient materials in the water, the quantity of invertebrate aquatic life, and the number and growth rate of the fish. For trout production a creel census would be the most direct method of securing results.

(3) Fertilize with organic or mineral fertilizers, the amount and quality of which would be largely determined by the cost and the known effectiveness of the materials.

(4) Continue the estimation of the productivity of the lake in its various phases to determine the efficacy of the procedure.

6. STREAM IMPROVEMENT

In this discussion of stream improvement we intend to confine ourselves to pool formation by the erection of dams

in the stream bed.

This type of stream improvement might be applied in at least three situations: (1) in a stream which once supported trout but in which the stock has been entirely depleted; (2) in a stream which supports trout in declining numbers; (3) in a stream which has and can support a good population of small trout.

Pool formation aims primarily at increasing the volume of water. In the first two cases mentioned above, this objective may assist in the successful planting of fish as well as in the creation of a habitat where the fish may attain a larger size. In the third case, there is no need to increase the stock of trout, and the objective has its fulfillment in the production of larger fish.

Stream improvement in its various phases has been applied widely during recent years, particularly in the United States. Favourable results have been secured in some instances, but with much of the work the aims and results of the procedure are rather obscure. To adopt the procedure in the Maritime provinces only the general principles should be accepted. Details should be evolved to meet local conditions.

There is no question that tests of this procedure are desirable in the Maritimes. These tests, however, should follow a definite plan. As with other fish cultural procedures it is necessary, in the test cases, to determine the conditions before, during and after its application if it is to be properly evaluated. With pool formation, one of the main objects is to ascertain the changes in the status of the fish

population, not only of the trout, but of the other species found in the habitat. Pool formation will alter the quality and quantity of aquatic organisms, i.e. fish foods. Thus, bottom fauna work is required, particularly in those sections of the stream which will eventually be pool bottoms. Therefore, the sites of the dams should first be located. Pool formation will also change the temperature conditions of the water. It follows that temperature records are important. In general, at least one year's records on the various phases of the problem are required before the dams are erected.

There are many possible sites for testing the procedure in the Maritimes. Dams have been erected in Burpee brook, tributary to the St. John river near Fredericton, but the conditions prevailing before and after the work was done are to a great extent unknown. This stream offers good possibilities, however, for testing the procedure further, not only in consideration of the general conditions prevailing in the stream itself, but also from the fact that the stream flows through government controlled land. (The stream flows through the Acadian Forest Reserve).

In Burpee brook the purpose of pool formation would be to create better conditions for maintaining a larger trout stock as well as to provide more suitable habitats for trout growth. Prince Edward Island streams, in many cases, due to good spawning grounds, abundant food, few predators, and a comparatively equitable water climate throughout the year,

contain a large stock of trout, but of small size. Therefore, on the other hand, these streams offer excellent opportunities to test the effectiveness of the procedure for increasing the size of the fish only.

As indicated in the forepart of this memorandum, the discussion does not include all procedures that might come to mind. Accordingly, we have not discussed such measures as predator bird control, forage fish propagation, improvement of spawning grounds, building of fish shelters, and others. We believe, however, that the procedures above discussed should receive first attention.

M. W. Smith,
Atlantic Biological Station,
December 8, 1938.