THE MANAGEMENT OF LARGE IMPOUNDMENTS FOR FISH PRODUCTION

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Only a propensity to "protrude thre neck" would cause one to consider the presentation of a paper dealing with the management of fish in large reservoirs. I do not think I know how to properly manage a large impoundment for fish production. I suspect that you people properly doubt my ability to formulate the needed prescription. I would go further, I doubt that we as a group or as variously arranged committees can draw plans for reservoir management that we would insure to be successful.

Because of the numerous items involved in management and the difficulty encountered in the measurement and evaluation of the items, I want to review some conditions which I consider basic. These conditions should be evaluated for each reservoir before management steps are to be considered.

THE NATURE OF RESERVOIRS

Reservoirs are depressions in the earth's surface with a dike or dam constructed across the natural drainage in such a way that water becomes impounded in the depression. There can be as many shapes and sizes of reservoirs as there are depressions. The reservoirs vary in many ways. The primary purpose for which the reservoir is built limits the characteristics of the reservoir. When constructed for flood control, hydroelectric power, irrigation or municipal water supply the thinking of the planning committee seems to be limited to water capacity in acre feet. A few small reservoirs have been constructed supposedly for recreation and fish production. Such reservoirs were in general built on private land that had limited choices of locations and the only patterns available were the flood control or water supply reservoirs.

The location of the reservoir generally predetermines the nature of the impoundment. Locations selected in the Northern states produce reservoirs that yield different fish crops than similar reservoirs in the Southern states. Climatic and edaphic differences in regions will cause reservoirs to have different potentials. There will also be great differences in reservoirs that are constructed in the same region. Local conditions of watershed, soil, basin bottom, shape of the basin and rainfall cause differences in the reservoirs. We have one in Northern Oklahoma that drains a large salt flat. That reservoir is different from our others. The reservoirs vary one from another, sometimes in different characters and generally in degree of quality of specific characters. The variances are difficult to analyze and often more difficult to control.

INDICES OF PRODUCTIVITY

Management of a reservoir for fish production implies that a desirable fish crop is the product produced. In order to manage a reservoir we should know the various processes and materials that make the product possible. One way to evaluate general productivity is to study the nature of reservoirs that exist.

I want to consider some of the more evident variable characters of reservoirs. I prefer to call the items "indices of general productivity." Measurements of productivity have been variously defined and as variously denied. Nevertheless, some standards or measurements for productive potential must be used. I shall mention five indices of general productivity for standing waters which function in the southwest (and elsewhere). I realize fully that these are not all that must exist, that the five are not all inclusive and that they are not completely understood.

1. Other items being equal the longer the shoreline, the greater the productive potential.
2. Other items being equal the greater the area of shallow water, the greater the productive potential.
3. Water exchange in the reservoir prevents the increase of fertility beyond that possessed by the runoff water.
4. Soils suspended in the water can drastically decrease light penetration and photosynthetic action thus resulting in decreased productive potential.

5. A fertile watershed contributes fertility to its reservoir and therefore makes possible a greater productive potential.

The first two of the indices are interrelated in that a relationship of soil to water is expressed. The indices are physical but have a controlling influence upon the biotic processes and populations. Each index can exist in different degrees in each impoundment and can change from time to time in a given impoundment. Thus we have five different variables that influence both singly and in combination the productive potential of each reservoir.

The influence of the indices can not be controlled easily once the primary purpose is determined, the location chosen, and the dam constructed. The location and dam height determines the amount of deep and shallow water possibly, the shoreline-length ratio, and the size and type of the watershed involved. The primary purpose of the reservoir (flood control, hydroelectric power, irrigation) along with the watershed size and rainfall of the area determine the amount of water exchange. The soil and soil conditions of the watershed largely determine the turbidity and therefore influence the food production in the water.

The initial filling of the reservoir basin is usually accomplished in a short period of time. The bottom land of the basin is generally fertile and usually possesses a large supply of plant material including roots, stems, leaves, humus, etc., when inundated. The plant material present soon dissolve. The plant crop is not replaced because of inundation. The water of the new impoundment is rich with life giving substances acquired from the dissolved crop. This makes possible a population of well-fed, fast growing fish.

If the water exchange is great the fertile waters of the initial inundations are replaced with waters fresh from the hills and valleys above. If the watershed is fertile good water continues to replace that which has gone down the river. If the watershed has been leached and is not fertile, the incoming water will be poor in life giving substances. In either case the second filling is never as productive as the first.

FISH POPULATIONS

I feel certain you are familar with fish populations and fish population tendencies. As one moves from one ecological area to another, one finds variations in the species that become dominant numerically. Some species are restricted to areas because of climatic requirements. Many of the species common to cold water can not tolerate the warmer waters and the warm water species do poorly in cold water. The natural lakes apparently have been experimenting for years with species combinations while our reservoir system, particularly in the Southern states, is in its infancy. It seems possible that we have produced a water area for which nature has not produced all of the kinds of fish that are needed to maintain balanced populations. More likely we do not as yet understand what combinations are best. Likewise some of the well-balanced natural lakes are not doing as well as we had first assumed. Certainly in many of the stabilized lakes the sustained yield is low. An impoundment can be expected soon to have populations that become overabundant. Many times the individuals become stunted. Some of the kinds of fishes that become abundant are: white crappie, white bass, gizzard shad, channel catfish, drum, buffalo, river carpsucker, carp and suckers. Others are likely to be overabundant at times, too. Probably all kinds become stunted when overabundant but I am not aware that stunting has been recorded as frequently among gizzard shad, drum, buffalo, carp and suckers. There are many instances in which I would like to invoke Dr. H. S. Swingle's repression factor. Maybe it has actually been operating with the latter group.

MANAGEMENT APPROACHES

Once a reservoir is in operation it is difficult to change its nature. Given time the shoreline will shorten and the basin fill. Generally the part of the basin first filled with silt will be the shallow areas where runoff water enters the reservoir. Siltation thus reduces the ratio of shallow to deep water. The water exchange value can not be reduced because of the primary purpose for which the impondment was built and the lower holding capacity causes a greater rate of exchange. Fertilization of large reservoirs does not seem to be a practical approach because (1) water exchange removes the fertility with the water making continued fertilization necessary, (2) fertilization is too expensive, (3) fertilization merely changes the point of balance between fish members and food supply to a new level.

Improvements should be made on the watershed. A watershed improvement program should pay in returns from both the land and the water. Increased fertility from the improved watershed will produce a higher level balance. Decreased turbidity by erosion control should be both practical and profitable. Decreased erosion on the watershed should increase the life expectancy of the reservoir.

In our efforts to manage reservoirs for fish production we are faced with the problem of maintaining a balance between the numbers of fish and their available food.

Since fish population soon become large and since an increase in food production seldom keeps pace with demand, we must turn our attention more and more to obtaining a greater harvest of the fish crop. Only by consistent and adequate harvest can the proper balance or management be attained. Harvests are necessary for every kind of fish produced in the impoundment, whether they be a game species or some of our so called "rough fishes".

METHODS OF HARVEST

Several methods have served to increase the harvest of fishes from reservoirs. I have arranged the methods in what I consider a decreasing order of importance. I have no scientific basis for the arrangement.

1. *Advertisement of the Impoundment*

Newspaper accounts of fishing successes and pictures of the catches have attracted the public to reservoirs. It seems that one need not tell the complete truth. If one hundred parties go fishing and two of them return with good catches, publish accounts and pictures of the two good catches. Consistent reports of good catches, though the percentage of good catches be terribly low, has induced Americans to persistently and frequently visit a given reservoir. The practice seems to be more commonly used on reservoirs of low productivity. It should be more successful for reservoirs that have good fish crops.

2. *Educate the Fishermen to Catch more Fish*

Tell people where in the reservoir and how to catch specific kinds of fish. The T. V. A. has led in such a program by their water temperature studies. Some State Departments have offered instruction in the art of catching certain kinds of fish. Successful fishermen as instructors can explain and demonstrate methods which will generally increase the harvest. Increased efficiency should increase the harvest.

3. *Concentrate the Fish in Convenient Areas when Possible*

Fish concentrations lead to a greater harvest. Feeding the fish about fishing docks has some promise. The concentrations of fish by the use of electric lights both by using white and colored lights offers some hope and should be investigated. Brush shelters offer points of concentrations and when marked so the fishermen can locate the areas often lead to increased harvest. Winter fishing at points of concentration caused by an inflow of warm water can be extremely effective. Sportsmen harvested 27 pounds of crappie per surface acre for the entire reservoir in Canton Reservoir, Oklahoma, during a nine-week period in 1950. Few lakes have 27 pounds per surface acre of all kinds of fish harvested in a year. Certainly the various means of fish concentrations should be studied.

4. *Commercial Fishing*

Only a few kinds of fishes have been shown to be sufficiently harvested by hook and line method. Many kinds are not harvested at all when only one method is used. Still these fish live and die in the impoundment, consuming and storing the food and energy without contributing to a profitable harvest. Not only do they escape the harvest but they use food and space essential to fishes that are in demand.

It would be easy at this point to condemn the unharvested fishes, stating that carp, suckers, drum, buffalo, river carpsuckers, shad, etc., are weed fish and should be liquidated. Rather I believe we should condemn the management methods that prevent or at least fail to insure a commercial fishing program. The commercial fishing program should lead to a more complete utilization of the food and energy produced in a reservoir. Game species that are insufficiently harvested by sport fishing should be included.

5. *Stocking of Carnivorous Species to help Control Forage Fish Populations*

A large number and variety of carnivorous fish should help to regulate the population size of the forage fish. The addition of a carnivorous species to a reservoir has resulted in an added source of sport fishing. White bass have been added to reservoirs in which gizzard shad were numerous and at least good white bass fishing has resulted. Walleyed pike have been planted in reservoirs for the similar reason. In Oklahoma the walleyed pikes have grown well, but to date no evidence of reproduction has been recorded. The effect on the numbers of forage fish is not known. The stocking of adult black bass in reservoirs where they are already present has been suggested as a means of controlling forage fish. Usually the large bass are difficult to acquire and such experiments have been tried only on small impoundments. Studies pinpointed to show the effect upon forage fish would be helpful.

6. *The Fluctuation of Water Levels to Interfere with the Spawning of Certain Species and to Concentrate the Fish for Greater Predation*

The runoff periods do not always occur at the same time or for the same length of time each year. Flood control reservoirs tend to fluctuate in volume rapidly during and following runoff periods. Water supply, irrigation, and water power reservoirs are often fluctuated to a much greater extent. The pattern of rainfall for the region in which the reservoir is located can modify the amount and time of fluctuation. Sometimes water can be released at opportune times to expose fish nests that were built in shallow waters. In some areas where water supply and irrigation are the primary purposes of the reservoirs it may be difficult to obtain a controlled fluctuation at spawning times. Water demand has caused complete drainage of reservoirs. Water level fluctuation must effect the rate of predation by compelling the small fishes to expose themselves in open water and in areas new to them. Many of the fishes must be carried away during the reservoir overflow. I am not aware of studies that answer the question of increased predation because of lowered water levels or of studies that explain the kind and rate of escape of warm-water fishes with water release.

Additional studies and alertness for opportunities should make water level fluctuation a useful tool.

7. *Rotenone Poisoning*

The harvest of surplus fishes by applications of rotenone has become a common procedure. The practice varies from poisoning small arms or bays to whole reservoirs. Partial poisoning tends to decrease the size of populations while complete poisoning should have the added effect of removing undesirable kinds of fishes. Rotenone has been used in attempts to do selective poisoning. The condition desired is a low concentration of rotenone to destroy species that are particularly susceptible to the poison. It seems difficult to so spread or apply rotenone in a body of water that some of the areas will not receive, temporarily at least, large concentration. Complete rotenoning is a drastic method which generally removes the reservoir from fishing use for one summer. Nevertheless, it does harvest fish.

8. *Draining and Refilling the Reservoir*

A reservoir must be in rather bad condition before one suggests that it be drained. If the dam is about to be washed away or the basin has silted nearly full and must be excavated or the water has become so muddy and the fish crop so poor that nothing else is acceptable and the community has plenty of other water, you drain the reservoir.

While draining you worry about erosion below the dam, the fish that will not be present to harvest, the chance that rains may set in before the basin is drained and the slow rate of drawdown. Once drained you worry for fear of rain before the work is completed and then worry for fear it will not rain. I don't know how many reservoirs you people have drained—you haven't published the experiences. I have drained six fairly sizeable reservoirs and haven't published my experiences either.

The reservoirs we drained had muddy waters with plenty of fish but few of them large enough to use. We drained the reservoir and planted the bottoms with sorghum, oats, smartweed and millet to provide a supply of organic material to enrich the new water and to coagulate and precipitate the suspensoids. Some of the reservoir's water cleared, remained clear and produced good fish crops after refilling. One of the reservoir's remained dry for two years. Then it rained, the reservoir filled, the fish crop grew exceptionally well and it rained and rained some more, exchanging the fertile water with its dissolved organic matter for fresh runoff water with no fertility. We were back where we were before we started.

If there is a next time, I shall insist that we use a watershed program that will at least slow the rate of water exchange.

I have tried to review the problems of fish production in reservoirs in 30 minutes. I have stressed variation in reservoirs and some difficulties one is apt to encounter in attempts to change the characteristics of the impoundment. I have tried to show that productivity can be evaluated through indicies.

I believe we should consider a more complete harvest as a management tool. The crop must be harvested. Why should we improve the impoundment, stock more fish and fertilize the water to raise a greater number of poorer fish to not harvest?

STOCKING AS A MANAGEMENT TOOL IN TENNESSEE RESERVOIRS

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The Tennessee Game and Fish Commission is responsible for the fisheries management of 26 major impoundments (or parts thereof) which total approximately 400,000 acres. The Tennessee Valley Authority has built or acquired, since 1933, nineteen of these impoundments in the Tennessee Valley area. Two dams are owned by private companies and five have been constructed by the U. S. Army Corps of Engineers.

Seven reservoirs on the Tennessee River and two on the Cumberland are main river projects and include navigation locks which permit upstream movements of fish. Dams are not effective obstacles to fish moving downstream. It may be assumed, therefore, that ecological preferences are the major influence on the distribution of fish from the Ohio River at the mouths of the Tennessee and Cumberland rivers to the bases of the storage reservoirs in east and north central Tennessee. All species of game fish and rough fish found in Tennessee storage reservoirs are found in the main stream impoundments. Certain desirable species were occasionally missing from tributary stream projects when their dams were constructed. This paper deals primarily with the known introductions made into these storage reservoirs. Its purpose is simply to summarize available information on the relative success or failure of each introduction and the resulting effect on the sport fishery.

The introduction of a desirable new species which shows up in the creel is a tangible example of reservoir management that the fishing public can appreciate. In a typewritten report dated December 28, 1944, to the Tennessee Conservation Department, Dr. R. W. Eschmeyer of the Tennessee Valley Authority wrote, "In those storage lakes where crappie are not present, they should be (and have been) introduced." However, the records of those introductions and probably those of other species have been lost or forgotten. The oldest introductions recorded in this summary are in 1948.

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GIZZARD SHAD AND MISSISSIPPI THREADFIN SHAD

Early in the history of Tennessee reservoir management, gizzard shad, *Dorosoma cepedianum* (Le Sueur), were credited with being the principal inter-