In not one study during the past eight years have crappie represented more than a trace percentage of the fishes taken in these samples.

In Cumberland Lake, a deep lake, crappie growth in one section of the lake is slow, the fish are abundant and are taken in rotenone studies to a degree closely approximating their relative abundance. In other sections of Cumberland Lake, crappie growth is more rapid, the population is composed of larger fish, they are quite abundant and the population studies fail to furnish even a close approximation of their relative status in the population.

White bass populations are extremely difficult to determine. In Herrington Lake, one study was made in which white bass were completely absent. The next year in the same area they were quite abundant. In another study, in 1950, 126 pounds of white bass were taken and the following year in the same area only four pounds of this species was recovered. The white bass represented 32 percent of the weight in 1950, and only four percent in 1951.

The populations of walleye and sauger are also difficult to determine from rotenone studies and examples could be cited; however, the pattern is quite similar to that concerning crappie and white bass.

The reasons why rotenone samples are not usually adequate for sampling pelagic and school fish populations are apparent. These fishes are constantly moving from one area of the lake to the other. They may be in the test area or they may not. They may move into the area or they may not. The large fishes of these species seek out the greater depths and are difficult to sample.

In summary, it can be said that rotenone population studies are of great value to our understanding of the population of a body of water. There is a wealth of information to be gained from these studies, if we know what data can be used with validity and what data cannot.

Each study should be conducted with a predetermined knowledge of what information is to be gained. Development and refinement of techniques and methods of conducting these studies should continue. It is believed that in the future studies should be made at all seasons of the year and that individual sample areas should be considerably larger than most study areas have been in the past. Of primary importance, however, is a thorough understanding of objectives.

HOW SHOULD POPULATION SURVEYS BE MADE?

By Charles J. Chance
Tennessee Valley Authority
Norris, Tennessee

The panel on "Population Studies" has limited its papers and discussion to "Standing Crop and Its Composition." This paper titled "How Should Population Surveys be Made?" is an attempt to fulfill an assignment on the panel.

Population estimation (*e. g.*, standing crop and its composition) depends upon counts of total populations or samples. Devices used to capture or confine fish for such purposes are largely modifications and applications of devices long used to capture fish for food or sport. With the exception of electro-fishing contrivances many date back to the beginnings of civilization (Cleary and Greenbank, 1954).

Total population enumeration, while perhaps the most accurate and reliable method known, is often impractical or impossible except in small water areas. For large waters like the TVA reservoirs (600-158,000 acres) and for routine evaluation of most smaller impoundments, sampling is the only practical way to acquire the population information that is needed to formulate sound fish conservation practices.

The diverse ways and means of sampling are a matter of record and well known to members of the Southern Division of the American Fisheries Society. I shall limit my discussion to the "rotenone method" as it is applied on TVA storage and multipurpose reservoirs. The list of panel subjects indicates that other methods will be discussed by other panel members and the membership.

Rotenone sampling is one of the most adaptable survey methods ever used to study fish populations in TVA waters. Its earliest use in the Tennessee Valley dates back to 1939, when Tarzwell (1940) sampled a 1.78-acre pond in Lauderdale County, Alabama, with derris powder. In 1941, he used this same material in the backwaters of Wheeler Reservoir. This first study in a TVA reservoir consisted of three samples totaling 12 acres. Also in 1941, Eschmeyer (1943) analyzed the population in a 1.4-acre embayment in Norris Reservoir. In 1952, Chance and Miller summarized developments in the use of rotenone in TVA reservoirs.

Our methods and equipment closely resemble those described by Swingle (1953). However, fisheries biologists are well known for their devising, improvising, and incorporating, and in TVA we are no exception. Our current practice is outlined below.

POPULATION SAMPLING PROCEDURE

Time of Sampling

Sampling is usually done during the period July through September. Water temperatures range from 75° to 84° F.

Site Selection

In Connection with stream or river sampling, Cleary and Greenbank (1954) state that "since poison presumably kills all or nearly all fish in a sampled area, the sample is representative of the total population to the extent that the sampled area is representative of the entire body of water. True randomness of sampling locale is difficult to obtain." Carlander (1956) summarized it pretty well with respect to sampling for growth studies when he said "probably the best we can do at present is to sample as widely as we can and then continually be critical of our sampling." We select one to three apparently typical sampling sites per reservoir. Deep-water sites are excluded because our cove sites sometimes run 45 to 75 feet deep and are probably outside the depth range for effective sampling.

The availability of manpower, boats, and motors are factors that decisively limit sample size. This season (1957), for example, our crew usually included at least five boats and ten men. We felt that this group could do a fairly clean job on samples ranging from one to four acres, depending on the reservoir. In one instance this fall we sampled a 10.9-acre area with ten men and five boats. Although we recovered 1,306 pounds of fish (120 pounds per acre), we were compelled, on the second day, to ignore almost completely several thousand small fish in order to recover the larger fish and prevent the development of nuisance conditions.

We prefer that sampling stations be close to the main body of the reservoir. This permits subsurface and surface currents to dilute the rotenone quickly and thus reduce or eliminate the kill outside the sample area. If the interior sections of large coves are used, excessive kills may result.

Dissolved Oxygen and Temperature Determination

Verticle series of D.O. and temperature records are made to determine whether an O_2-depleted density current or a thermocline are likely to be operative factors in sampling. D.O. is determined by the Alsterberg (azide) modification of the Winkler method and temperatures are obtained with a Foxboro electrical resistance thermometer.

Surveying Surface Area of Sample

Beginning this year we substituted stadia measurement for "guesstimating" the surface area of water included in our samples. The need for accurate determination became evident when we discovered that visual estimates might be 25-100 percent in error. If sample data are to be used as quantitative estimates of total fish population, accurate measurements of sample area is imperative.

The stadia is sufficiently accurate (1:500) and shots can be made over water and rough terrain and as frequently as desired. Often the transit does not have to be moved and shots can be vertically angled over brush, rocks, or other obstructions and then corrected. Errors are compensating and not cumulative.

After a sample is mapped, computed area and shoreline can be correlated with number or weight of fish.

Sounding

Average water depths are determined by sounding with a weighted line and mechanical depth meter. Readings are taken at frequent intervals along lines that traverse the sample area. Knowing average depth and area, it is a simple matter to compute the volume of all or any part of the sample area.

Toxicant

Our early work was done with derris powder. Because of its versatility and ease of handling, we began using 5 percent emulsifiable rotenone in 1952. It is applied at the rate of 0.5 to 1.0 p.p.m. This year we were forced to use a synergic formulation of emulsifiable rotenone part of the time. In one reservoir the synergic formulation yielded 42 pounds of fish per acre while the 5 percent emulsifiable rotenone yielded 240 pounds per acre. To us this emphasizes the importance of using a toxicant that is reliable and constant. Switching from one formulation to another introduces an unnecessary variable.

Method and Manner of Application

The rotenone is dispersed into the water by a 5,000-gallon-per-hour Homelite pump. The pump intake line picks up water outside the boat. Rotenone is added to the intake water by means of a valve cut-off assembled to provide a venturi action. It is well mixed by the pump before it passes into the outlet line.

The rotenone-water mixture is discharged through 90 feet of plastic hose. The last 40 feet of this hose has ⅛-inch holes drilled at 18-inch intervals. The perforated hose is weighted and in most cases reaches from bottom to surface.

One-third to one-half of the "open" or lake side of the sample is saturated with rotenone from top to bottom. In most instances, the remaining portion receives a lighter dosage. This establishes a differential rate of kill and simplifies fish recovery.

Fish Recovery

Each sample area is worked two days. All available fish are picked up the first day. Then the area is cleaned up the second day.

Recovery is by dip net. We have tried scoops attached to the boat for collecting small fish but so far this arrangement has been unsatisfactory. We believe it has merit, however, and intend to continue some development work along this line.

Processing

All fish are sorted by species, measured to the nearest inch, and weighed on dairy scales to the nearest 0.1 pound. If some species are few in number and too small to weigh to the nearest 0.1 pound they are weighed on more sensitive scales to 0.01 pound. Fish selected for scale samples are measured to 0.1 inch and weighed to 0.01 pound. (Exact Weight Speed Production Scales, The Exact Weight Scale Company.) Weights of fish collected the second day are based on fresh fish weights of the same size class collected the first day.

As a rule, young-of-the-year gizzard and Mississippi threadfin shad, because of their great numbers, are enumerated on the basis of samples. If 150 pounds of young-of-the-year shad are collected, number and size classes for the lot may be based on a 5-pound sample.

Data Compilation

When these data are tabulated the number, weight, and size class of each species are recorded. Percentage composition of the sample is computed from species and sample totals. These compilations comprise the basic data. Interpretations and manipulations beyond this point depend on the need, use, and inclination of the investigator.

RESULTS

A few results of rotenone sampling in accurately measured sample areas are shown below:

Reservoir	Sample Area (Acres)	Total Weight Fish Recovered	Weight Fish Per Acre
Wheeler *	6.5	1,891.0	291.5
Wheeler *	1.1	914.0	831.0
Wheeler *	4.4	828.0	188.2
Wheeler *	19.0	14,999.0	789.0 †
Norris *	1.4	192.4	139.0
Norris	3.1	230.2	74.3
Norris	6.5	283.0	43.7
Norris	8.8	1,059.4	120.4
South Holston	3.9	155.8	40.0
Watauga	5.2	197.7	38.0
Cherokee	2.8	629.5	225.6
Fort Loudoun	3.0	874.8	292.6
Fort Loudoun	3.7	804.0	217.3
Watts Bar	3.1	513.4	168.3
Watts Bar	1.8	178.6	98.7
Chickamauga	10.9	1,306.2	119.7
Chickamauga	2.3	475.5	205.8
Douglas	1.9	80.6	42.2
Douglas	2.8	664.5	240.0

* Samples taken in 1941; all other samples taken in 1957.

† Rounding area to nearest 0.1 acre resulted in 2 pounds per acre less than recorded in original data.

As mentioned earlier, the unplanned use of a highly recommended sampling agent in 1957 yielded quite unsatisfactory results. This probably accounts for a great deal of the variance in 1957 yields.

Sampling in TVA reservoirs has been done with limited manpower to meet special needs. In most cases we felt that accurate surveys of sample areas were not justified. Data from such areas are not abundant; however, the following 1956 yield-per-acre data from cove areas of estimated size are listed for comparison and illustration:

Reservoir	Estimated Sample Area	Total Weight Fish Recovered	Weight Fish Per Acre Recovered
Norris	2.0	305.9	152.9
Norris	2.5	309.2	123.7
South Holston	2.0	758.3	379.1
Watauga	2.0	170.1	85.0
Cherokee	2.0	382.5	191.2
Fort Loudoun	2.0	302.9	151.4
Kentucky	1.0	121.2	121.2
Kentucky	2.0	420.0	210.0
Wilson	1.0	235.0	235.0
Wheeler	1.0	642.0	642.6
Guntersville	2.0	476.3	238.1

SPECULATIONS

Qualitatively, we are satisfied with the results of our work with rotenone. We feel that with few exceptions composition ratios are adequate for our present needs. Quantitatively, the method certainly has limitations but this is also true of other methods. We have not used rotenone samples specifically to estimate "standing crop." Applying sample data to a 100,000-acre reservoir would yield some very impressive, but admittedly speculative crop figures.

If it is urgent that we have precise standing crop estimates to solve practical management problems, then the sampling procedures should be planned to meet that objective. We might expect that research groups, units, or academic institutions that are free and unhampered by the day-to-day imprecations of license buying fishermen, could better and more easily attain such a goal. The field biologist, no doubt, can contribute a great deal but in his current role he probably does not have time or justification to engage in unlimited standing crop studies.

There are three main reasons why rotenone sampling has limited value as a quantitative measuring device: (1) The incomplete recovery of fishes as verified from various marking and recapture experiments and described in the literature, (2) the possibility of the movement of fishes into and out of the sample area, and (3) the inadequate number of samples for a given body of water.

With respect to the first source of error, depth, bottom topography, underwater obstacles, and the time factor make it almost impossible to mark fish prior to sampling. Would marking freshly killed, recovered fish from the study area and returning them to the area provide an adequate estimate of unrecovered fish? Where light transmission is sufficient, could Scuba be used to determine the unrecovered portion of the sample? One suggested solution involves large squares of weighted cheese cloth placed on the bottom and then retrieved.

We need to know more about fish movement into and out of treated areas. Until we do, mechanical barriers are recommended. Perhaps diving equipment (Scuba) would permit direct observations on the reaction of fishes at the edge of the treated water, especially in cove samples. Many have assumed that considerable movement occurs, but in our multipurpose, storage reservoirs most observations show negligible "drift kills" outside the sample areas. Where they do occur, the species most affected is gizzard shad. Open- or deep-water samples present a different and perhaps more complicated problem in this respect.

The third limitation—adequacy of sampling—can be minimized but we doubt that it can be completely eliminated. The real limiting factor here is inadequate funds and time. Related to adequacy of sampling is the possible effect of water-level fluctuation on standing crop estimates. For example, TVA flood control policy demands that tributary and mainstream reservoirs be at their lowest level on January 1. Highest levels are reached by May or June. During summer and fall reservoir levels gradually trend toward the January 1 minimum. Therefore, throughout most of the growing season our reservoirs normally undergo continuous reduction in level and area. For example, the area of Norris Reservoir may be reduced from 34,200 acres at spillway elevation (1,020 feet above sea level) to 12,300 acres at elevation 950 in mid-October (an area reduction of about 67 percent). At what point on an area rate-of-change curve would standing crop data be most representative of a body of water? Whether such a seasonal decline in the area of large waters is important, or whether Carlander (1955) considered it when he concluded that available data show no significant correlation between standing crop and area of a body of water, is not clear to the writer.

Earlier we referred to "open" or "deep-water" samples and our meager experience with them in storage reservoirs. This type sample plot is laid out to include an area of open water. One boundary is usually the shoreline; the other boundary lines lie off shore. The dimensions of such a sample area are not fixed as in cove samples. This poses a geometrical question. Should the sample area be square or rectangular? If rectangular, should the long dimension be parallel or perpendicular to the shore? We need an experimental answer to this question.

To us, these appear to be the most important considerations concerning standing crop determination. Undoubtedly there are others. Our discussion of how to make population surveys is based on our own experience. We trust that experience may be of value to others.

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AN EVALUATION OF FISH POPULATION STUDIES BY FLORIDA HAUL SEINE

By HAROLD L. MOODY
Florida Game and Fresh Water Fish Commission
Fisheries Experiment Station
Leesburg, Florida

ABSTRACT

The technique of operation of the haul seine as traditionally used in the large fresh water bodies of Florida is discussed. Limiting factors inherent in the sampling device are enumerated and illustrated by seine catches from several lakes. Rotenone studies from some of these lakes are contrasted with the seine catches. The results of creel census studies in lakes extensively fished by sportsmen, by reflecting proportionate quantities of game fishes similar to quantities taken in the haul seine, are quoted as further validation for its use in qualitative population sampling. Difficulties in quantitative sampling by this method are discussed. It is shown to be of questionable value when employed for approaching absolute terms such as productivity in pounds per acre except in certain special cases. The value of the haul seine for purely relative comparisons is emphasized.

A little more than ten years ago quantitative data regarding Florida's fresh water fish populations were almost non-existent. A rapid increase in sportfishing produced social and economic pressures which caused official outlaw of the commercial sale of gamefishes. Angry rebuttals from the commercial fishing interests were followed by the Florida Commission's establishment of lacustrine studies. At first concentrated on the St. Johns River and Lake Okeechobee, these investigations utilized the traditional Florida haul seine as the principal sampling device (Dequine, 1951). Detailed records of thousands of individual seine hauls and their accompanying temporal circumstances were eventually accumulated from many lakes throughout the state; thus our present large-scale program of sportfishing improvement was born.

The basic principle involved in seining is the physical surrounding of a volume of water, from surface to bottom, with a net, and the capture of the fishes thus confined. A body of water may be completely or partially enclosed by the seine. Mesh size as well as degree of water coverage determines quantities of fishes taken. It also obviously governs minimum age and size classes of fishes available to it (Huish, 1954). A knowledge of net dimensions and amount of water area covered is essential for sampling evaluations.

The commercial haul seines used in Florida were of large size, measuring from several hundred feet to about a mile in length. The minimum mesh consisted of webbing from two inches to four inches, stretched measurement.