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AN EVALUATION OF SOME OF THE FACTORS AFFECTING THE VALIDITY OF ROTENONE SAMPLING DATA

By Victor W. Lambou and Herbert Stern, Jr.
Louisiana Wild Life and Fisheries Commission
Baton Rouge, Louisiana

The rotenone method of sampling fish populations is widely used throughout the southeast, and is generally accepted as the best available method for obtaining complete information about fish populations in most natural lakes and man made impoundments. However, as Swingle (1950) has pointed out, the information obtained often contains certain inaccuracies. Nevertheless, many workers accept the data without considering these inaccuracies. Because of this we would like to critically evaluate some of the factors which affect the validity of rotenone sampling data.

Tarzwell (1942) compared the results of fish population studies obtained from rotenone poisoning, gill nets, set lines, seining, hoop nets, and sport fishing records and concluded that the rotenone poisoning yielded the most complete information about the fish population—the other methods were considered to be selective for certain species and size groups of fish.

Swingle (1950) discussed how incomplete recovery of fish following rotenone poisoning can affect the accuracy of the data obtained. Several workers (Krumholz, 1944; Ball, 1948, and others) have reported varying percentages of previously marked fish recovered from rotenone samples. According to Swingle (1950) many workers make little attempt to include complete records of small fish with their sampling data. Serious bias can result from the failure to adequately account for small fish and the variation in the amounts of fish recovered from different samples due to incomplete kill and/or pick up of fish.

There seems to be little standardization of the methods used to take rotenone samples. Some workers surround the area to be sampled with nets; other workers mark the area to be sampled with floats; while still others simply apply a curtain of poison around the sample area. A standardization in methods

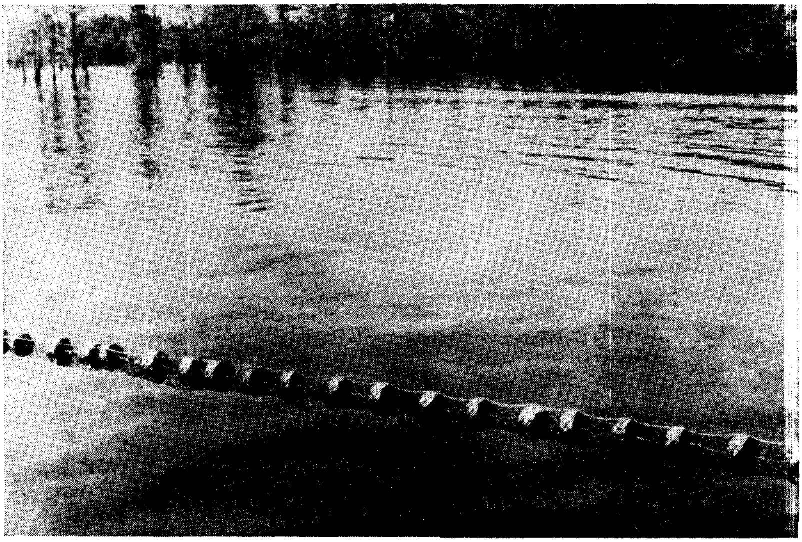


Figure 1. Block-off net used in taking rotenone samples of fish populations.

is necessary if samples, not only from the same body of water but from different water bodies, are to be compared. If this is not done, it is doubtful that any comparisons made will be valid because of differences in the completeness of recovery of fish from the sample areas.

In order to obtain samples which are comparable, we feel it is necessary to surround the sample area with some type of block-off net. Consequently, most of the samples we have taken from Louisiana waters were surrounded by a one-inch square mesh block-off net with the corks spaced close together on the float line and the netting hung over the corks (Figure 1). This arrangement of the float line prevents waves from washing floating fish out of or into the sample area and according to our observations, it is rather successful in accomplishing this except when the water is extremely rough.

The use of a block-off net has many advantages. It accurately delimits the sample area. It prevents fish, except very small individuals, from leaving or entering the treated area. It prevents fish which are selectively killed on the outside of the sample area, such as shad, from being included in the sample. From our observations, we have learned that the inclusion of shad which are selectively killed on the periphery of the sample area can seriously bias the data. The block-off net prevents the inclusion in the sample of predaceous fish (such as gar fish and bass) which are attracted by the dying forage fish.

We feel that considerable attention should be given to the standardization of the methods of taking rotenone samples. The advantages are obvious. Samples taken from different bodies of water and by different workers could be more readily compared.

Any method of sampling will be more or less selective. However, rotenone sampling has the advantage, if sufficient attention is given to how the samples are taken, of not being extremely selective for any particular kind or size group of fish. It appears that the main inaccuracy associated with this method is that varying percentages of fish occurring in the sample areas are recovered. Additional investigations relating to the various conditions which affect the completeness of recovery of fish would be invaluable. If sufficient attention is given to the problem of obtaining samples in which the ratio of non-recovered fish to recovered fish is of approximately the same magnitude, then rotenone sampling should furnish a fairly accurate index by which the species composition and standing crop of fish in different bodies of water can be compared.

In rotenone sampling, very little attention is given to the number of samples needed to make an estimate of the fish population within certain confidence limits. Many investigators seem content to take three or four samples, average the data obtained, and accept it as an accurate estimate of the fish population. But, how accurate are data obtained from three or four samples?

In order to get some insight as to the sample size (*i. e.*, number of samples) needed, the variability of the total pounds of fish per acre occurring in rotenone samples taken from Lake Bistineau (Figure 2) and Caddo Lake were measured.

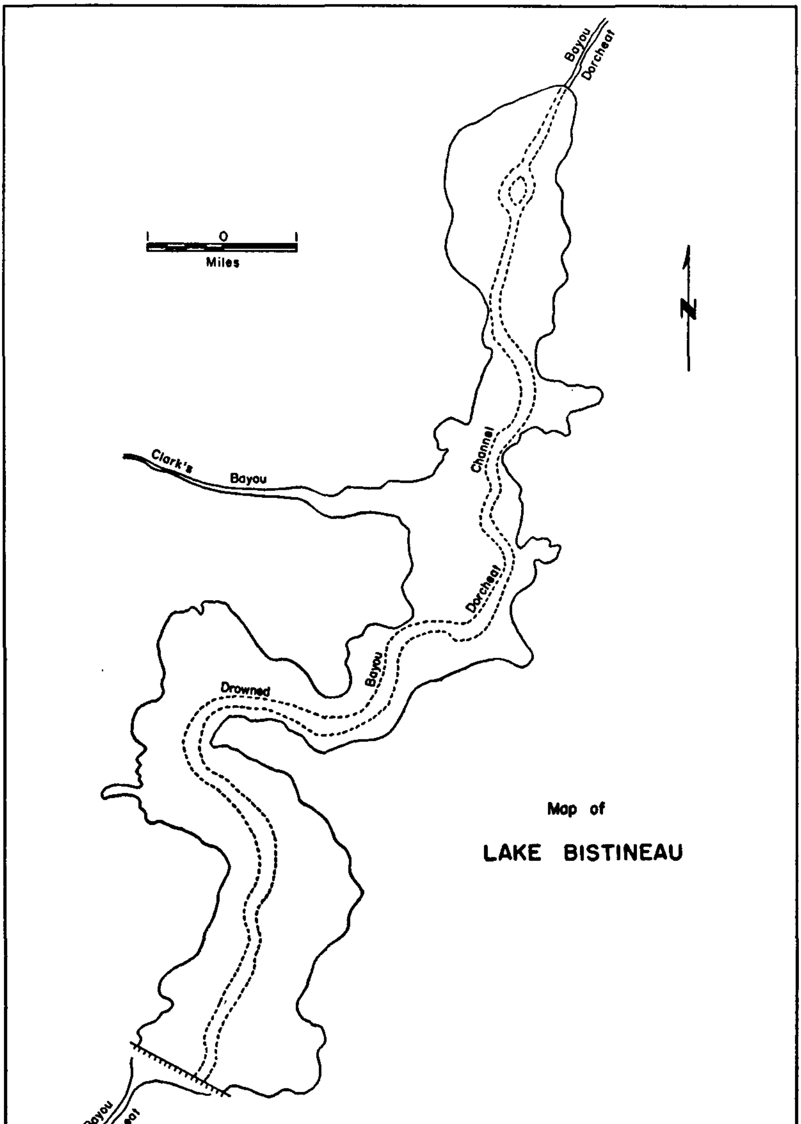


Fig. 2

Both lakes are large impoundments, 17,200 and 10,100 * acres respectively, located in northwest Louisiana. Even though the lakes are large, they are rather shallow and it is possible to take samples from almost all areas of either lake.

The data obtained from eighteen one-acre rotenone samples taken from Lake Bistineau during the late summer and early fall of 1955 were analyzed. The samples were grouped for summary purposes as follows:

Sample Group No. 1—includes all samples taken from upper third of the lake.

Sample Group No. 2—includes all samples taken from middle portion of the lake.

Sample Group No. 3—includes all samples taken from lower third of the lake.

Sample Group No. 4—includes all samples taken from the old drowned Bayou Dorcheat Channel—this includes samples taken from the areas where, generally, the greatest depths of water occur.

Sample Group No. 5—includes all samples not taken from along the shoreline or from the old drowned Bayou Dorcheat Channel—this includes samples taken from the areas where, generally, medium depths of water occur.

Sample Group No. 6—includes all samples taken from along the shoreline of the lake—this includes samples taken from the areas where, generally the shallowest depths of water occur.

Sample Group No. 7—includes all eighteen samples.

The data obtained from ten one-acre rotenone samples taken from Caddo Lake during the summer of 1954 were also analyzed.

The means, standard deviations and coefficients of variation were computed and are given in Table I. All the coefficients of variation in Table I are large, indicating that the pounds of fish per acre occurring in the rotenone samples were quite variable.

TABLE I

VARIABILITY OF TOTAL POUNDS OF FISH PER ACRE OCCURRING IN ROTENONE SAMPLES TAKEN FROM LAKE BISTINEAU AND CADDO LAKE

Lake Bistineau:	*Sample Size*	*Mean*	*Standard Deviation*	*Coefficient of Variation*
Sample Group No. 1	4	223.7	175.09	78.27
Sample Group No. 2	8	78.6	41.69	53.04
Sample Group No. 3	6	112.0	95.33	85.12
Sample Group No. 4	5	88.3	52.11	59.01
Sample Group No. 5	8	130.0	153.18	117.83
Sample Group No. 6	5	142.7	76.10	53.33
Sample Group No. 7	18	122.0	110.24	90.36
Caddo Lake	10	31.5	18.95	60.16

Sampling data are often stratified in order to reduce the experimental error. Sample groups 1, 2 and 3; and sample groups 4, 5 and 6 can be considered as two different stratifications of the samples taken from Lake Bistineau. These stratifications are by location on the lake. Some of the strata had smaller coefficients of variation than the unstratified sample (sample group 7). However, some of the strata had coefficients of variation almost as large and in one instance larger than the unstratified sample. Therefore, it is probable that there would be very little or no advantage in stratifying the samples taken from Lake Bistineau. Stratifying rotenone samples of fish populations taken from large bodies of water by type of habitat or in some similar manner is rather difficult because it is necessary to have an exact knowledge of the strata; that is, it is necessary to know exactly what constitutes the strata and the exact boundaries of the strata. Small errors in the weighing of strata may introduce enough bias to nullify any gain from stratification.

Another type of stratification should be considered; that is, stratification of the samples by species of fish. Each species of fish constitutes a separate population and therefore it seems reasonable to assume that the pounds of fish per

* 10,100 acres includes only that portion of the lake located in Louisiana—an additional 32,000 acres are located in Texas.

acre for an individual species might be less variable than the total pounds of fish. However, the exact opposite might be the case, as the pounds per acre of a species of fish occurring in a sample probably has some relationship to the pounds of fish per acre of other species occurring in the sample. We have not analyzed the data to determine if stratification by species will reduce the experimental error; however, it is intended that this will be investigated in the future.

According to Senedecor (1946) the sample size needed for the sample mean to be within a given percent of the true mean for a given probability can be estimated according to the following formula:

$$N = \frac{t^2 c^2}{p^2}$$

Where N = sample size
t = t value for a given probability
c = coefficient of variation
p = percent that sample mean is within true mean

Estimates were made of the sample size needed for the means of the samples taken from Lake Bistineau and Caddo Lake to be within a given percent of the true mean for a given probability. These estimates are present in Table II and are shown graphically in Figures 3 and 4. It is readily seen that a large number of samples must be taken in order to estimate the total pounds of fish per acre to any degree of accuracy.

In instances where the sample comprises over five percent or more of the population, a correction factor is usually used in computing the standard error. This is done because the possibilities of variation becomes less as the sample size approaches that of the population. This was not taken into consideration in estimating the sample sizes in this report and therefore in some instances a larger sample size is indicated than the area of the lake. However, it is extremely improbable that any investigator will be taking a sample of five percent or larger from a large lake. Five percent of the area of Lake Bistineau and Caddo Lake is 860 and 505 acres respectively.

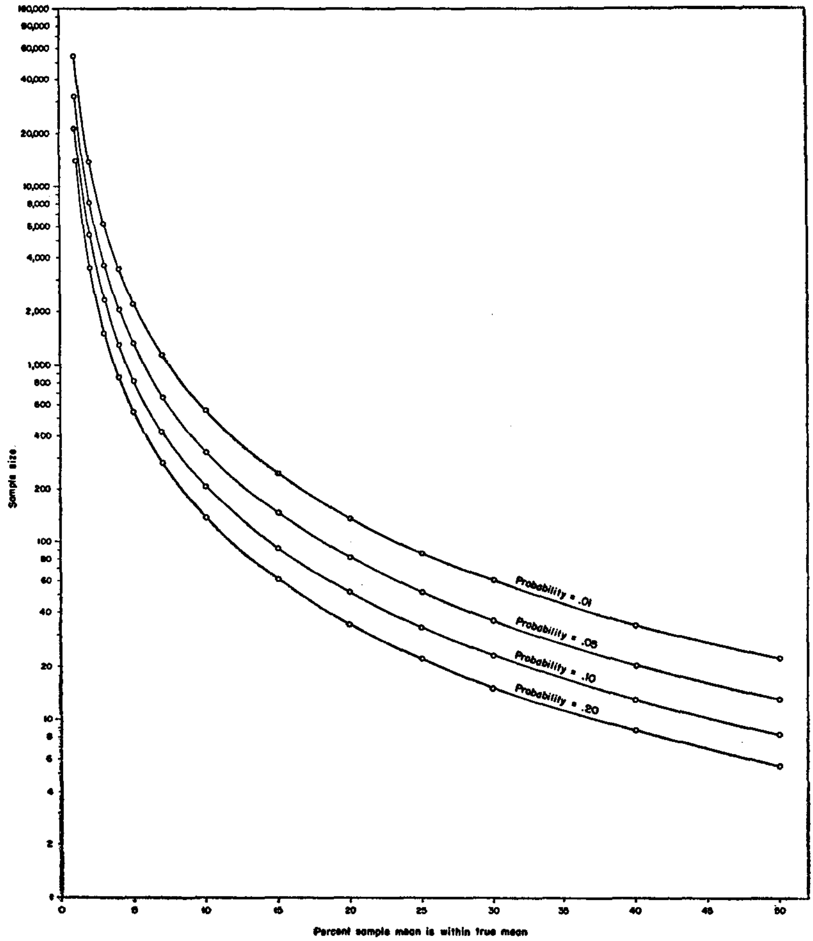
The pounds of fish per acre occurring in rotenone samples taken from different bodies of water should have different coefficients of variation. This should be especially true for samples taken from different types of lakes. However, it is reasonable to assume that the amount of variation occurring in samples taken from lakes similar to Lake Bistineau and Caddo Lake will be in the same general range. Therefore, the data presented here should give some indication as to the sample size required in sampling such lakes.

TABLE II

ESTIMATED SAMPLE SIZE NEEDED FOR SAMPLE MEAN (TOTAL POUNDS OF FISH PER ACRE OCCURRING IN ROTENONE SAMPLES) TO BE WITHIN A GIVEN PERCENT OF THE TRUE MEAN FOR A GIVEN PROBABILITY

	Coefficient of Variation							
	90.36—Lake Bistineau				*60.16—Caddo Lake*			
Percent	*Probability*				*Probability*			
of Mean	*.01*	*.05*	*.10*	*.20*	*.01*	*.05*	*.10*	*.20*
1	55,195	32,660	20,902	13,799	24,466	14,477	9,265	6,117
2	13,799	8,165	5,226	3,450	6,117	3,619	2,316	1,529
3	6,133	3,629	2,322	1,533	2,718	1,609	1,029	680
4	3,450	2,041	1,306	862	1,529	905	579	382
5	2,208	1,306	836	552	979	579	371	245
7	1,126	667	427	282	499	295	189	125
10	552	327	209	138	245	145	93	61
15	245	145	93	61	109	64	41	27
20	138	82	52	34	61	36	23	15
25	88	52	33	22	39	23	15	10
30	61	36	23	15	27	16	10	7
40	34	20	13	9	15	9	6	4
50	22	13	8	6	10	6	4	2

Fig. 3 Estimated size of sample needed for sample mean (total pounds of fish per acre occuring in rotenone samples from Lake Bistineau) to be within a given percent of the true mean for a given probability.

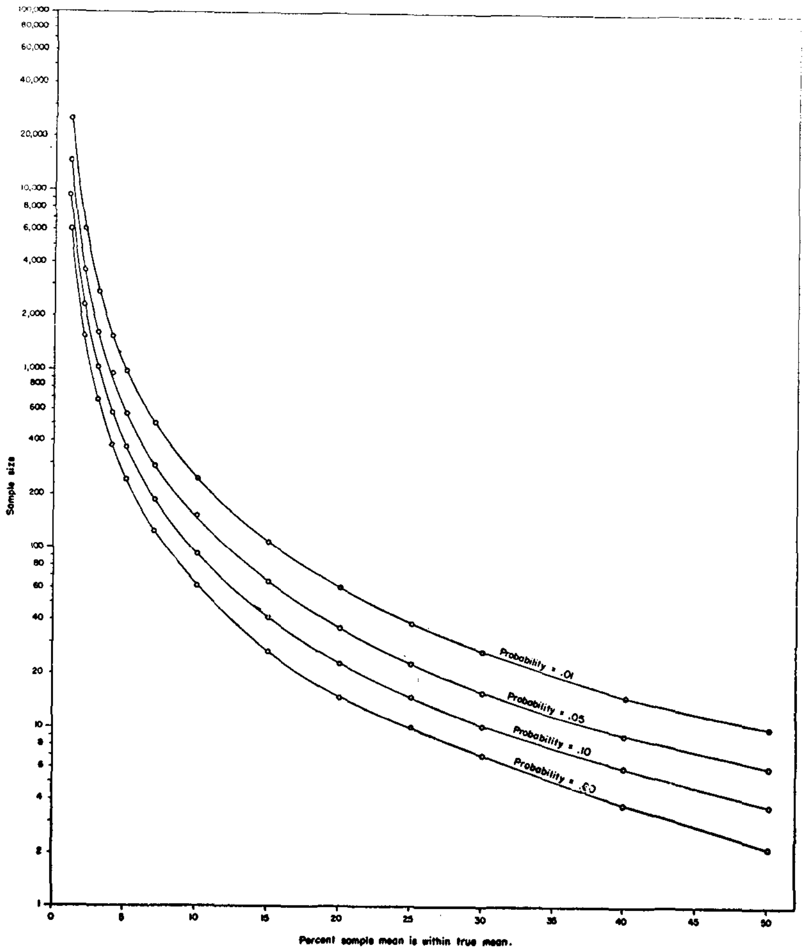


Additional critical studies are obviously needed to determine the sample size required. This is especially true for different types of lakes and for lakes located in different sections of the country.

Most of the advantages of rotenone sampling over other methods are obvious; however, there is one disadvantage in this method which is usually not considered. In sampling, one of the most efficient methods of reducing the experimental error is to increase the sample size. Obviously, it is impractical to increase the sample size greatly in rotenone sampling.

The problem of how the sample sites should be selected in rotenone poisoning is rather perplexing and is worthy of considerable attention. In sampling large bodies of water containing diverse habitats, it is desirable to sample each of the environments present. This is seldom possible because the investigator is often limited by factors beyond his control. Usually the investigator can take only a limited number of samples and certain physical characteristics such as

Fig. 4 Estimated size of sample needed for sample mean (total pounds of fish per acre occuring in rotenone samples from Caddo Lake) to be within a given percent of the true mean for a given probability.



extreme depth and close proximity to human habitation can eliminate portions of a lake as potential sampling sites.

Any arbitrary selection of sample sites introduces bias to the data obtained from such samples, as sampling theory is based on randomization. It was quickly evident to us in a review of the literature that some workers have arbitrarily selected sample sites on the basis of sampling ease and accessability. This surely cannot be considered as random or stratified random sampling, and data obtained from such sampling can contain serious bias. The importance of how the sample sites are selected cannot be over-emphasized because the validity of the data is directly dependent on it.

In conclusion, the factors affecting the validity of rotenone sampling data can be grouped into four general types: (1) the selectivity of the method, (2) variation in the amounts of fish recovered from different samples due to incompleteness of kill and/or pick-up of fish, (3) the sample size and (4) the method used in selecting the sample sites. All four factors are important and need to be considered in the planning of rotenone sampling studies.

ACKNOWLEDGMENTS

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A BRIEF APPRAISAL OF DATA ANALYSIS METHODS EMPLOYED IN DETERMINING STANDING CROPS OF FISH

By Robert M. Jenkins
Oklahoma Fishery Research Laboratory
Norman, Oklahoma

The need for the extension and refinement of our ability to estimate the size and composition of fish populations is widely recognized as paramount. Optimum yield prediction—the essential ingredient of management policy—cannot be attempted unless the fishery worker has concrete evidence of the total standing crop involved. The increasing number of detailed standing crop studies now being undertaken must, therefore, be accompanied by the development of better methods of field estimation, statistical treatment, and presentation.

LARGE LAKE ANALYSIS

In conducting detailed population analyses of large lakes, pilot mathematical models should be constructed if possible and referred to during the course of the study. Without a carefully conceived plan, time, energy and funds can be lost by collecting insufficient or superfluous data. The advisability of advance planning in mark-and-recapture standing crop studies is underlined by the work of Cooper and Lagler (1956) in laboratory experiments with colored beans. Using a two-gallon minnow pail with internal rotating baffles as a "lake", and beans as "fish", they observed the mechanics of indirect sampling methods under controlled conditions in order to gain an understanding of estimation methodology and to test assumptions appearing in field applications. The bean experiments afford clues to the number of days required to obtain a "good" estimate with sample size and total population size previously established.

An example of the applicability of their laboratory models to field studies is afforded by the conduct of estimations of crappie populations in 184-acre Ard-