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SUGGESTED STANDARD METHODS OF REPORTING FISH POPULATION DATA FOR RESERVOIRS PREPARED FOR THE RESERVOIR COMMITTEE, SOUTHERN DIVISION OF THE AMERICAN FISHERIES SOCIETY

By EUGENE W. SURBER
Branch of Federal Aid, Bureau of Sport Fisheries and Wildlife
Atlanta, Georgia

During a meeting of the Southern Division's Reservoir Committee on June 1, 1959, the writer was directed by the Committee to review methods of reporting fish population data for reservoirs and to recommend a standard method.

In carrying out this project, it was necessary to keep in mind certain of the objectives in presenting population data. Reservoir workers, Wiebe (1942), Smith and Miller (1943), Tarzwell (1942), have observed that rough fish have increased in numbers following the early years of good sport fishing. The importance of determining the ratios of game fishes to rough fishes in large impoundments has been emphasized by Eschmeyer, Stroud, and Jones (1944), Trazwell (1945) and more recently by Hall (1951).

Carter (1958) listed a number of reasons for collecting fish population data by rotenone sampling. Among them were the determination of species composition, standing crop, abundance of adult fish, success of natural reproduction, and information on year classes.

Southern biologists have been uniform in methods of collecting and recording the basic data. Field data sheets have invariably recorded each species of fish present in a population sample in one inch size classes. The weights of fish in each size class are generally recorded, therefore the two prime basic units for calculation of population dynamics are generally available. As stated by Chance (1958), "Interpretations and manipulations beyond this point depend on the need, use and inclination of the investigator."

Jenkins (1958) observed the need for extension and refinement of our ability to estimate the size and composition of fish populations as well as methods of field estimation, statistical treatment and presentation. He considered standard forms for recording the original field data a prime requisite.

A STANDARD METHOD

The following Tables I-V, labelled "Summary of Fish Population Data for Reservoir . . . .," represents the organization of the field data approved by the Reservoir Committee. The actual field data may be recorded on a simple form (included in this report) which gives the size class of each species of fish, the total number of each species, and the total number and weight of fish of available size, or the harvestable fish.

Key to Species Grouping __A__

TABLE I

SUMMARY OF FISH POPULATION DATA FOR RESERVOIR ________________

Species	*Fish of Available Size*			*Intermediate*			*Fingerlings*		
	Nearest Inch Class And Up	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*
A. *Predatory Game Fish*									
Largemouth Bass	9			5–8			0–4		
Smallmouth Bass	9			5–8			0–4		
Spotted Bass	9			5–8			0–4		
Striped Bass	10			5–9			0–4		
White Bass	7			5–6			0–4		
Yellow Bass	6			4–5			0–3		
White Crappie	7			5–6			0–4		
Black Crappie	7			5–6			0–4		
Walleye Pike	12			5–11			0–4		
Sauger	12			5–11			0–4		
Chain Pickerel	12			6–11			0–5		
Northern Pike	16			7–15			0–6		
Muskellunge	24			7–23			0–6		
Rainbow Trout	7			5–6			0–4		
TOTAL									

Key to Species Grouping __B__

TABLE II

SUMMARY OF FISH POPULATION DATA FOR RESERVOIR ________

Species	Fish of Available Size			Intermediate			Fingerlings		
	Nearest Inch Class And Up	No. Per Acre	Pounds Per Acre	Nearest Inch Class	No. Per Acre	Pounds Per Acre	Nearest Inch Class	No. Per Acre	Pounds Per Acre
B. *Non-Predatory Game Fish* (Panfish)									
Bluegill Sunfish	5			3–4			0–2		
Longear Sunfish	5			3–4			0–2		
Orangespotted Sunfish	–			2			0-1		
Redbreast Sunfish	5			3–4			0–2		
Redear Sunfish	5			3–4			0–2		
Spotted Sunfish	5			3–4			0–2		
Green Sunfish	5			3–4			0–2		
Pumpkinseed	5			3–4			0–2		
Flier	5			3–4			0–2		
Rock Bass	5			3–4			0–2		
Warmouth	5			3–4			0–2		
Yellow Perch	6			4–5			0–3		
White Perch	6			4–5			0–3		
TOTAL									

Key to Species Grouping __C__

TABLE III

SUMMARY OF FISH POPULATION DATA FOR RESERVOIR __________

Species	Fish of Available Size			Intermediate			Fingerlings		
	Nearest Inch Class And Up	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*Acre No. Per*	*Pounds Per Acre*
C. *Non-Predatory Food Fish* (Commercial Species)									
American Eel	16			8–15			0–7		
Carp	14			7–13			0–6		
Drum	10			5–8			0–4		
Paddlefish	23			8–22			0–7		
Smallmouth Buffalo	16			5–15			0–4		
Bigmouth Buffalo	16			5–15			0–4		
Chubsucker	10			5–9			0–4		
Carpsucker	12			5–11			0–4		
Quillback	12			5–11			0–4		
Spotted Sucker	12			5–11			0–4		
Redhorse Sucker, Sp.	12			5–11			0–4		
White Sucker	12			5–11			0–4		
Yellow Bullhead	7			5–6			0–4		
Black Bullhead	7			5–6			0–4		
Brown Bullhead	7			5–6			0–4		
TOTAL									

Key to Species Grouping ___D___

TABLE IV

SUMMARY OF FISH POPULATION DATA FOR RESERVOIR ______________

Species	*Fish of Available Size*			*Intermediate*			*Fingerlings*		
	Nearest Inch Class And Up	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*
D. *Predatory Food Fish* (Commercial Species)									
Channel Catfish	10			5–9			0–4		
Blue Catfish	10			5–9			0–4		
White Catfish	10			5–9			0–4		
Flathead Catfish	10			5–9			0–4		
Alligator Gar	24			7–23			0–6		
Longnose Gar	26			7–25			0–6		
Shortnose Gar	24			7–23			0–6		
Spotted Gar	24			7–23			0–6		
Bowfin	14			5–13			0–4		
TOTAL									

Key to Species Grouping __E__

TABLE V

SUMMARY OF FISH POPULATION DATA FOR RESERVOIR ____________

Species	*Fish of Available Size*			*Intermediate*			*Fingerlings*		
	Nearest Inch Class And Up	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*	*Nearest Inch Class*	*No. Per Acre*	*Pounds Per Acre*
E. *Forage Fish* (Non-Predatory)									
Gizzard Shad	8.0			4–7			0–3		
Threadfin Shad	–			–			–		
Golden Shiners	6.0			4–5			0–3		
Gambusia	–			–			–		
Starhead Topminnow	–			–			–		
Killifish	–			–			–		
Misc. Minnows	–			–			–		
Misc. Darters	–			–			–		
Madtom	–			–			–		
TOTAL									

Field Sheet No. 1

FISH POPULATION SAMPLE

Name of Reservoir KENTUCKY

Location EAGLE NEST COVE

Date OCT. 23, 1958 Group A PREDATORY GAME FISH

Method of Sampling ROTENONE, COVE

Stage (?) Area Sampled Acres

By

Size and Class	*Largemouth Bass*		*Spotted Bass*		*White Bass*		*Yellow Bass*		*White Crappie*	
(Inches)	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
1	–	–								
2	5	T*							(	
3	49	0.60	1	T			38	0.45	(187	1.02
4	8	0.16	1	T	1	0.05			3	0.07
5	16	1.00			3	0.10			3	0.20
6	5	0.50			14	1.40			8	0.80
7	6	0.90			15	2.90			20	3.40
8	–	–							17	4.30
9	1	0.40							19	7.10
10	–	–							3	1.50
11	1	0.70			2	1.50			6	4.40
12	1	0.90							13	13.10
13	2	2.10			1	1.10			4	4.70
14	1	1.40							4	6.00
15	1	1.80			1	1.60				
16	–	–								
17										
18										
19										
20										
TOTAL	96	10.46	2	T	37	8.65	38	0.45	287	46.59
AVAILABLE	7	6.90	–	–	4	4.20	–	–	86	43.50

T* = trace.

The species of fish are grouped as follows:

Group A. Predatory Game Fish—bass, crappies, trout, etc.

Group B. Non-predatory Game Fish—sunfish, rock bass, perch, etc.

Group C. Non-predatory Food Fish—carp, drum, buffalo, suckers, bullheads, etc.

Group D. Predatory Food Fish—catfish, gar, bowfin, etc.

Group E. Forage Fish (Non-predatory)—gizzard shad, threadfin shad, Gambusia, minnows, etc.

In the summary form, in addition to showing the minimum available size for each species, space has been provided to show the number and weight of fingerling fish and fish of intermediate sizes per acre. If per acre data are not to be calculated, number and weights only can be given.

In recording the basic data on the field sheet, the worker in the field will save time if he groups those species of fish present as they have been grouped above and in the same order listed across the top of the field sheet. Fish of available or harvestable size can then be indicated by drawing a line over the size class interval that represents the available size for a given species. An example of a filled-in sheet is attached.

In the "nearest inch" method of measuring fish commonly used by reservoir workers, a 9-inch largemouth bass in Group A includes fish from 8.5-9.4 inches in length. Total length is used.

DISCUSSION

The determination of F/C Y/C, A_T, and E values after the method of Swingle (1950) are possible from the above groupings. The reader is cautioned that these values had their origin in fish population relationships determined quantitatively in farm ponds. F/C and A_T values have been most widely used. F/C is the ratio of the total weight of all forage fish to the total weight of all carnivorous (*Piscivorous*) fishes in a population. The weight of "F" species, or the "F" value equals (in farm ponds) the weight of bluegills (including available sizes) plus the weight of small plus intermediate black crappies. Referring to Group B of this *Standard Method,* all of the non-predatory game fish (pan fishes) might be placed into the forage group, including yellow perch which reach 10 inches in length or more in northern waters. More often, perch are rather small in size, running 7 inches or less in length so they have been placed in the pan fish group. Like the green sunfish, warmouth, and rock bass they are piscivorous at times.

In the Swingle system, the "C" value equals the weight of all bass (including small sizes) plus the weight of all crappies weighing more than 4 ounces. In population studies on reservoirs, sorting is by size groups and not weight, therefore, if the *Standard Method* is to be utilized in making "C" determinations, conversions of weight groups to size groups will be necessary. Swingle (1953, p. 50) furnished data (Table VI) which may be used to solve the conversion problem in part, at least.

Swingle (1950) classed all sizes of bass as "C" fishes. Then all sizes of piscivorous fishes might fall within the carnivorous group plus channel catfish, blue cats, flathead cats over a certain size. Bullheads, channel catfish up to two pounds, blue cats up to 3 pounds, and flathead cats up to 8 pounds were found by Swingle (1950) to compete with bluegills in farm ponds and were placed in the forage (F) group. Greater knowledge of the growth rates, food habits, and ranges in size of reservoir fishes under a variety of conditions is needed for the practical use of calculations of this type.

More studies of species of the type made by Foote and Blake (1945) on the chain pickerel *Esox niger* should be made. In a study of length-age relationships in Babcock Pond, Connecticut, 46.3 percent of the fish studied were three years old and averaged 12.3 inches (legal size—12 inches) in length. Only 14.2 percent of the fish studied were over 14 inches in length. While this study was not made in the South, it serves to focus attention on the need for actually determining available size which might not be as high as 16 inches for the chain pickerel, as listed in Table VI of this report.

TABLE VI

(AFTER SWINGLE, 1953) MINIMUM HARVESTABLE SIZES OF FISHES USED IN COMPUTING A_T VALUES

Species	*Weight in Pounds*	*Approximate Length in Inches*
Largemouth Bass	0.4	10
Spotted Bass	0.4	9
White Bass	0.3	9
Walleye	0.5	12
Chain Pickerel	0.7	16
Longnose Gar	1.0	20
Spotted Gar	1.0	17
Crappies	0.26	8
Sunfishes	0.1	6
Channel Catfish	0.3	10
Blue Catfish	0.3	10
Flathead Catfish	0.5	12
Freshwater Drum	0.3	9
Carp	1.0	13
Buffalo	1.0	13
Paddlefish	1.0	23
Skipjack	0.5	12
Mooneye	0.5	12
Gizzard Shad	0.5	11
Spotted and Redhorse Suckers	0.5	11
Carpsucker	0.5	10
American Eel	0.5	19

The A_T value (total availability value) is a very usable statistic. This is the percentage of harvestable fish in the fish population. Swingle (1950, 1953) proposed fishes of certain minimum weights for the determination of this value, but since it is more practical in the field to sort fishes into size groups and to weigh them collectively afterwards, the percentage of *harvestable* fishes based on certain minimum lengths as has been used quite extensively by TVA and Tennessee biologists is recommended in a *Standard Method.*

In the tables above "Fish of Available Size" has been used to denote those fishes of catchable or harvestable size.

The minimum lengths of fish of available size has been set by agreement within the Committee. The fact that a minimum available size for gizzard shad has been set may come as a surprise to other than TVA and Tennessee biologists. Swingle (1950) pointed out that large groups of unharvested adult fishes, regardless of whether they are bluegills or gizzard shad or another species, have a depressing effect upon the carnivorous or "C" groups. The A_T value calculated for fish populations determined by him was obtained by dividing the total weight of large fish by the weight of all fish. The range of balanced populations in farm ponds was 33-90 with the most desirable range 60-85 (percentage available).

A very large population of fish of "Intermediate" size often occurs in impoundments where water levels fluctuate little, and often where there is a large quantity of submerged vegetation present.

Stevenson (1959) determined the predator—non-predator ratios by weight and by number in Arkansas Reservoirs. The best fishing occurred in Lake Ouachita, a relatively new reservoir, with the lowest ratio by weight of the two groups (1:5.3). His method is recognized as a ratio comparable to the F/C ratio of Swingle (1950). Well balanced populations are apparently in the range of 1:3.0 to 1:6.0.

Swingle's Y/C ratio can also be determined with the above groupings, if desired. This ratio is the total weight in pounds of fish in the forage groups (of Swingle, 1950) that are small enough to be eaten by the average-sized adult (Fish of Available Size in this *Standard Method*) in the "C" or predatory groups, divided by the "C" value, or total weight of fish in the "C" or predatory groups. In formula form

$$Y/C = \frac{\text{Total pounds of "Small" fishes in the forage "(F)" group}}{\text{Total pounds of "C" or predatory species}}$$

According to Swingle (1950) the most desirable range appears to be 1.0 to 3.0.

Lawrence (1958) has estimated the sizes of forage fishes largemouth bass of different lengths can swallow. For example, 9.5 inch (total length) bass can swallow bass 5.19, bluegills 3.19, redears 3.19, green sunfish 3.41, golden shiners 4.69, goldfish 3.52, and gizzard shad 4.09 inches in total length. Such estimates as these based on actual measurements of many fishes can lead to more accurate determinations of carnivorous fish-forage fish ratios.

Lambou (1959) separated the fishes taken by quantitative rotenone sampling in Louisiana backwater lakes into predaceous and non-predaceous species. All species normally fished for by sportsmen were classed as game fish. Louisiana has no size limit on game fish, therefore the minimum sizes assigned for available game fishes were purely arbitrary. Available commercial fish were those of a size that could be sold legally.

Lambou (1959) observed an average of 1.9 pounds of non-predaceous fish per pound of predaceous fish in Louisiana backwater lakes. Values ranged from 0.4 to 4.8, however he noted that they were lower than found in other types of Louisiana waters. He considered the ratio of non-predaceous to predaceous fish of value, but observed that this ratio does not show the weight of forage fish these predators can use for food. He believes that this relationship can be determined from (1) total weight of predaceous fish of a size large enough to feed mainly on other fish or other forage animals (large crayfish), and (2) total weight of fish or other forage animals of a size small enough to be utilized for forage by the predators. The ratio of pounds of all fish under 5 inches to pounds of predaceous fish over 5 inches would give a better approximation of predator-prey relationships. Lambou included all kinds of fish in the prey group because he thought it probable that small fish of the kind that are predaceous when adult could be used as forage. Further, he thought it probable that very few fish over 5 inches in length are utilized as forage fish by the large predators. If the latter assumption were true, then the amount of forage fish available for the predators over 5 inches in length is the maximum amount possible and the calculation of the ratio would be of value for comparative purposes and for determining relationships in the population.

With uniform grouping, there is a good possibility that new ratios of use to the fishery biologist may appear as more experience and accuracy are gained.

INCREASING THE ACCURACY OF SAMPLING

Chance (1958) described current practices in the population sampling of coves in TVA reservoirs with rotenone. Some features of their procedure are briefly described. From one to three sampling sites per reservoir were selected. Deep-water sites were excluded because cove sites sometimes ran 45 to 75 feet deep. Coves of from one to four acres close to the main body of the reservoir were selected to permit more rapid dilution after the kill. They were carefully measured by stadia and sounded by mechanical depth sounder. One-third to one-half of the open or lake side of the sample was saturated first with rotenone from top to bottom at 0.5 to 1.0 p.p.m. with emulsifiable rotenone using a 5,000 gallon-per-hour pump which picked up water outside the boat and rotenone from a container insider the boat with valve cut-off assembled to provide a venturi action. The rotenone is well-mixed by the pump before being discharged through 90 feet of plastic hose, the last 40 feet of which had ⅛-inch holes drilled at 18 inch intervals. The weighted perforated hose in most cases reached from surface to bottom. The remaining portion of the cove received a lighter dosage, but sufficient to kill.

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

The fish are then sorted by species, measured to the nearest inch, and weighed on dairy scales to the nearest 0.1 pound. More sensitive scales [1] are available for weighing to 0.01 pound some species too few in number and too small to weigh to the nearest 0.1 pound.

There should always be on hand adequate personnel to pick up affected fish as soon as they surface, for the accuracy of the sample depends to a large degree upon the efficiency of the first day pickup. This efficiency has been increased in the North Carolina work by a fish scoop, designed by Donald Baker and Roby Biesecker of the Wildlife Resources Commission. This is bolted to the front end of a 14 foot boat (Figure 1).

The accuracy of cove sampling may be increased considerably by a block-off net of mesh small enough to prevent threadfin shad, gizzard shad, and other fast moving fishes from entering the sample. The *Standard Method* recommends a cove block-off net to be used which shall be at least 20 feet deep. The recommended cove block-off net shall be 500 feet long by 30 feet deep by ⅜-inch square mesh measurement made of 100 percent nylon. The cost of this net according to a quotation received recently by Georgia from a nylon net company [2] at Memphis, Tennessee, is $795.00.

While coves make ideal areas in which to collect fish population samples, in some impoundments particularly during low stages, there may not be any coves.

The *Standard Method* under this second condition, recommends the use of a block-off net similar to that described by Lambou and Stern (1958) and Lambou (1959) except the ⅜-inch square mesh measurement instead of one-inch mesh netting is recommended. They found a block-off net 280 yards long to be the most efficient size. A net of this size surrounds a one-acre area. If one side of the sample area happens to be the shore, the extra 70 yards of the net is placed on the shore. Lambou (1959) showed the cost of 280 yards of nylon webbing 20 feet deep (one-inch square mesh), No. 12 filament to cost $2,250.00 complete, including boat and lead lines, etc. A cotton net of the same length of No. 9 medium twine costs $485.00.

However, if ⅜-inch square mesh measurement nylon netting in a 30-foot depth can be furnished at a cost of about $1,135.00, even greater accuracy in sampling might be expected because of the ability to sample a wider range of depths.

The advantage of using a one-acre block-off net in open waters are the following: (1) It prevents fish from leaving or entering the treated area; (2) affected fish within a treated area attract predaceous fish such as gar which may consume large numbers of fish without being killed themselves unless they are excluded by netting; (3) time is saved in picking up fish because affected fish on the periphery of a sample area may be ignored as far as the sample is concerned; (4) large fish such as carp and buffalo cannot charge out of the area at contact with the chemical used; (5) a quantitative method is provided whereby gross comparisons may be made between areas within a reservoir or between reservoirs; and (6) since arbitrary selection of sampling sites invariably introduces bias to the data collected, a means of sampling by a random method is provided.

Large seines for sampling reservoir fish populations are not in current use in the South. They have been used extensively in Florida and the Midwest. Smith, Franklin and Kramer (1958) found that seines as short as 27 feet were reliable tools for fish up to two inches in length, but larger fish were more reliably sampled with 50-foot and large seines.

The following are only a few of the problems which have arisen in the preparation of this report that require a solution:

---

1 Exact Weight Speed Production Scales, The Exact Weight Scale Co., Columbus, Ohio.

2 Nylon Net Co., Memphis 3, Tennessee.

1. What ratios between groups of fish, or sizes of fish, will be of greatest value in revealing the best population structure with respect to maximum yield of game fish?

2. What are the food habits of green sunfish, warmouth, rock bass, eels, etc., in reservoirs?

3. Should sunfishes over 5 inches in length be classed as forage fishes in reservoirs in a ratio calculation similar to F/C, or does the ratio of pounds of all fish under 5 inches to pounds of predaceous fish over 5 inches give a better predator prey relationship?

4. At what population levels do rough fish such as drum, shad, carp, buffalo, gar, etc., become a problem in reservoirs?

5. What species and at what levels of abundance in reservoirs do the fishes of intermediate size depress growth rates of important game or food fishes?

6. Do several cove samples collected in a given reservoir during the same season represent the true fish population, or are they biased samples?

7. Are one-acre samples collected in reservoirs by day or by night with a block-off net more reliable than cove samples in showing the true structure of the fish population?

8. Which of the above two methods are most reliable in showing between year changes in fish populations?

9. What new equations for expressing fish population relationships characteristics of "good fishing" status are possible? It should be possible to devise a formula expressing the depressing effects of a large group of fish of intermediate size.

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THE TOXICITY OF NOXFISH AND PRO-NOXFISH TO EGGS OF COMMON CARP AND FATHEAD MINNOWS

By F. EUGENE HESTER *
Agricultural Experiment Station
of
Auburn University
Auburn, Alabama

ABSTRACT

Laboratory experiments were conducted to determine the toxicity of Noxfish (an emulsifiable formulation containing 5 percent rotenone) and Pro-Noxfish (an emulsifiable formulation containing 2.5 percent rotenone plus 2.5 percent Sulfoxide as a synergist) to eggs of common carp (*Cyprinus carpio*) and fathead minnows (*Pimephales promelas*). Spawning devices were added to brood ponds and examined daily to obtain eggs of known age for testing. The

* Resigned September 1, 1959. Present address: Zoology Department, N. C. State College, Raleigh, North Carolina.