FISH POPULATION ESTIMATE METHODS EVALUATED BY A TOTAL DRAWDOWN

JACK HERRING, Mississippi Department of Wildlife Conservation, P.O. Box 451, Jackson, MS 39205

Abstract: The fish population of Lake Columbia, a 36.42 ha Mississippi impoundment, was estimated by shoreline seining, mark and recapture, rotenone sampling and gill netting. The impoundment was then drained to evaluate results. Shoreline seining provided an excellent estimate of population balance. Mark and recapture of largemouth bass (*Micropterus salmoides*) gave a statistically valid estimate and was the only method to which statistics could be applied. Length-frequency data of bass from rotenone samples were stable and appear useful, although large bass were underestimated. Rotenone samples gave stable balance ratios, but standing crop varied greatly. Gill nets captured all major species and provided useful data on species not adequately represented in rotenone samples.

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The ability to estimate accurately standing crop of fish in impoundments is difficult. Of several methods currently employed, rotenone samples and mark and recapture are probably the most often used. Swingle's (1956) method of shoreline seining is used throughout the southeastern United States to determine bass-bluegill (*Lepomis macrochirus*) balance in small impoundments.

Population estimates by mark and recapture studies date back to Petersen (1896). Classical works are those of Petersen (1896), Schnabel (1938), Schumacher and Eschmeyer (1943), and Chapman (1951). Statistical analysis can be applied to determine validity of results.

Bennett and Brown (1968) estimated the fish population of a 106 ha Oklahoma Lake with 5 types of sampling gear before draining the lake. They concluded that electrofishing was the best method they evaluated. Sandow (1970), on a 36.4 ha Georgia Reservoir, found the average standing crop from 3 cove samples to average 60.6 kg/ha. Upon drainage, total standing crop was 54.2 kg/ha. Therefore, he concluded that cove rotenone samples provided the best methods for evaluating bass and bluegill populations. In a more recent study, Crandall, et al. (1976) found that gill netting and rotenone samples furnished good approximations of species present and the relative abundance of dominant fishes. In the Douglas Reservoir study, Hayne et al. (1967) found cove rotenone samples to be fairly representative of the entire arm. Woodrum (1978) used mark and recapture and rotenone samples in a 67 ha impoundment and found rotenone sampling to overestimate bass, while mark and recapture estimates of population size closely represented that found upon draining.

Several investigators (Bennett and Brown 1968, Powell et al. 1971, Crandall et al. 1976), have used gill nets to estimate the species composition and to supplement rotenone study data of various size lakes. The objectives of this study was to determine the best method of routinely estimating the standing crop and population balance of small impoundments.

MATERIALS AND METHODS

Lake Columbia, a 36.42 ha impoundment located in Coastal Plain soil of southern Mississippi, was checked for fish population balance during the summer by shoreline seining. Checks were made each month from April through September. Standardized seine hauls were made with a 4.6 m (15 ft.) and a 15.2 m (50 ft.) seine. Each seine haul was begun by holding 1 end of the seine stationary at the water's edge, while the other end was moved directly out into the lake. The mobile end of the seine was then moved back to the shore in an arc, sampling an area 1/4 that of a circle with the same radius. Five areas of the

lake were checked with both seine lengths. The 5 samples obtained with the 4.6 m seine were combined, and an average catch per seine haul was calculated for that day. Swingle's (1956) method of determining balance was applied to this average. The same procedure was used with the 15.2 m seine samples.

Bass were marked and recaptured by electro-fishing from 20 February through 17 April, 1978. During April, clear water, lack of cover and low conductivity made it difficult to capture bass. Night sampling was initiated and proved to be more efficient. Fish were marked with Floy FD-68 BC tags and released at the end of each sampling period.

The Schnabel (1938) method was used to estimate the bass population,

where $P = \frac{\Sigma m\,(u+r)}{\Sigma r}$

where m = total number of marked fish in lake
u = capture of unmarked fish
r = capture of marked fish
confidence intervals: $r + 1.92 \pm 1.96\sqrt{r+1}$.

Two rotenone fish population studies were conducted on Lake Columbia during August 1978, one 0.30 ha cove and one 0.40 ha shoreline. A 1.27 cm mesh block-off net was used to surround the sample area. Five percent emulsifiable rotenone (Nox-fish) was applied to the study area as evenly as possible through a pressure system until a concentration of 1.0 ppm was obtained.

Fish were collected, sorted by species, placed in size groups, counted, weighed and recorded. Second and third day pickup was processed in the same manner. Population data are presented as outlined by Surber (1959). Values, such as F/C, Y/C, and A_T are those proposed by Swingle (1950). Study data from 1976 and 1977 are also presented.

Monofilament experimental gill nets were placed in Lake Columbia during July, August and September. Hot water temperatures caused us to shorten our fishing periods, as most fish were dead and bloating within 12 hours. Sampling time was reduced to 24, 18 and 13 hour periods. Twenty-seven m of 3.8 cm bar mesh and 27 m of 5 cm bar mesh were used. Nets were fished near the mouth of coves and in open water. Captured fish were measured and weighed.

A collection basin was constructed on the downstream side of the dam to capture fish at draining. The basin, built of wood and 0.38 cm mesh screen, was designed to prevent injury to the fish during draining (Zurbuck, 1965). Very small fish could escape the basin. The 30.48 cm (1 ft.) valve was opened on 5 September 1978. The lake did not completely drain as planned. The fish remaining in the 2 - 3 ha of water were collected beginning 10 October 1978 by the use of rotenone. All fish collected over a 3 day period were sorted by species, placed in size groups, counted, weighed and recorded.

RESULTS AND DISCUSSION

Seine checks made from April through September, 1978, indicated an excellent spawn of young bass. All six 15.2 m seine checks indicated the lake to be in balance (Swingle, 1956). Four of six 4.6 m seine checks indicated overcrowded bass, while the remaining 2 samples indicated a balanced fish population. Upon draining, the lake was found to be overcrowded with bass; thus the 4.6 m seine appeared to give more accurate results.

Electro-fishing of bass for a mark and recapture study was conducted during early spring. A total of 217 bass greater than 254 mm were tagged from 20 February to 17 April, 1978.

The April bass population estimate was 952 fish >254 mm (Table 1), with 95% confidence intervals of 668 and 1362. In comparing the April bass population estimate with the actual October population, adjustments were made for bass growth during the summer of 1978. Age and growth studies by Herring (1976) in similar Mississippi

TABLE 1. Mark and recapture estimate of Lake Columbia bass population and 95 percent confidence intervals.

Date	No. Capt.	Total Marked	Total Recapt.	Pop. Est.	Confidence Low <N>	Interval High
2/20/78	27					
2/27/78	16	27	2	216	59	815
3/13/78	25	41	0	729	199	2749
3/16/78	48	66	4	1156	499	3005
3/20/78	22	112	5	1418	604	3344
3/23/78	7	132	5	1603	684	3780
3/31/78	8	139	5	1825	779	4304
4/4/78	39	147	13	1142	668	1958
4/6/78	37	178	21	1021	668	1562
4/10/78	20	192	25	1011	667	1494
4/17/78	16	207	30	952	668	1362

impoundments indicated that the 242-343 mm bass are the current year's recruitment. Therefore, to obtain a valid comparison, one should compare the bass >254 mm in the spring tagging with bass >343 mm in the October draining.

The actual population upon draining was 970 bass, while the spring mark and recapture estimate was 952. Thus, the mark and recapture estimate is well within the 95% confidence interval although mortality and tag losses are not considered.

Exploitation of a fishery can also be estimated by tagging. Angler return of tags is the normal method of determing angler exploitation, when used in conjunction with a mark and recapture study. Excellent angler participation is essential for valid results. Thirty-three tagged bass were recaptured, with 23 of these reported in the 3 weeks of electrofishing. Only 10 additional bass were reported captured for the entire summer. Seventeen tagged bass were recovered upon draining the lake. This leaves unaccounted 167 tagged bass. Natural mortality accounted for some lost bass but certainly not 167. It is concluded the tagged bass were caught and not reported. This lack of angler participation was not encountered in 2 earlier studies by Herring (1977 and 1978). Herring (1977) noted in a similar study that tag loss was obviously low.

Length-frequency is another method of determining the fish population in an impoundment. Figs. 1, 2, and 3 show the length-frequency of bass from rotenone samples during August, 1976, 1977 and 1978 respectively. Overexploitation of large bass apparently occurred each year. This apparent overharvest of large bass occurred with a fishing pressure of 73.0 fishermen trips per ha in 1976, 46.0 trips/ha during 1977, and 51.6 trips/ha during 1978. Length-frequency data of bass upon draining during October 1978 again confirms that the larger bass were apparently overfished (Fig. 4). Although the larger bass had been overfished, a strong 1978 young-of-the-year bass class was present. These young-of-the-year bass (5-6 months old) were 90 - 191 mm in total length.

Anderson (1976) and Anderson and Weitham (1978) described a Proportional Stock Density (PSD) index as the percentage of fish of a quality size that is longer than a minimum stock size. The PSD of bass should be approximately 40 - 60% in a well balanced impoundment. During 1976 this index, as derived from rotenone sample data, was 11.7% for Lake Columbia. 1977 and 1978 show an increase, with values of 28.7% and 25.7%, respectively. In October 1978 the PSD index determined by draining was 45.1%

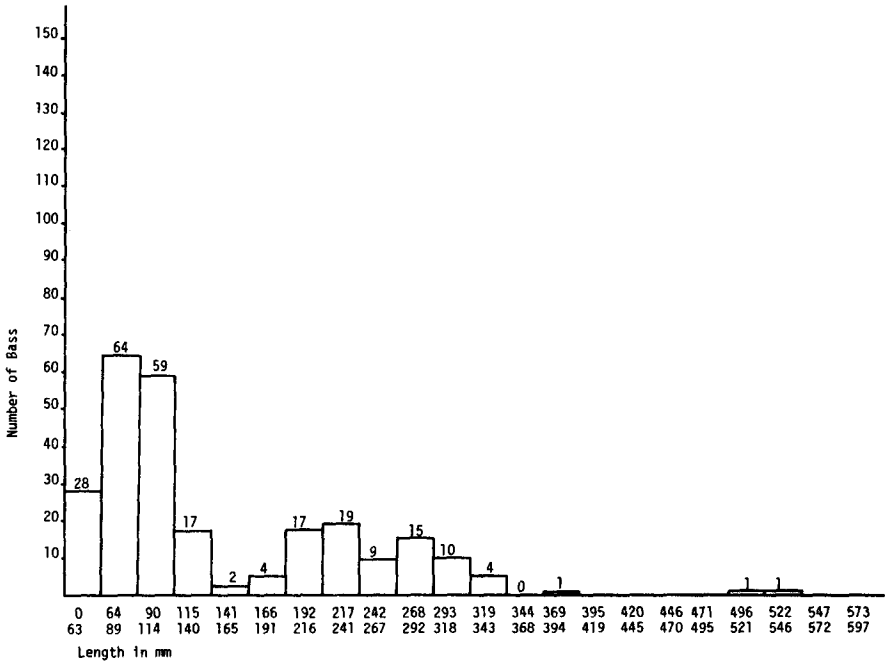

Fig. 1. Largemouth bass length-frequency in mm from rotenone samples 1976, 251 bass.

for bass. This differs from the 25.7% found by rotenone samples 3 months earlier. Length-frequency data from rotenone samples may not reliably estimate the bass population structure. It appears consistent but is generally low. Although a PSD value of 45.1% is considered good, the lake, upon draining, contained only 48 bass greater than 420 mm. I consider this to be a lack of large bass.

Rotenone population studies were initiated on Lake Columbia during 1976. Two studies conducted in July 1976 indicated a total standing crop of 90.84 kg/ha, while similar studies in 1977 showed a standing crop of 193.07 (Table 2). The 1978 cove and shoreline rotenone samples revealed a standing crop of 187.96 kg/ha. The 3 year average of 6 population estimates indicated a standing crop of 157.29 kg/ha. This is similar to the 150.67 kg/ha found upon draining, but individual studies ranged from 69.16 kg/ha to 282.74 kg/ha (Table 2). The 1978 standing crop of 187.96 kg/ha is near the actual standing crop upon draining.

It is apparent that rotenone samples vary greatly and that 1 or 2 studies each year are not consistent indicators of the standing crop. Similar values occur in comparing the bass populations from rotenone samples with those obtained by draining. Upon draining, 48.74 kg/ha of bass were found (Table 3). The average of 6 population studies gave 44.46 kg/ha for seemingly valid results, while 2 1978 studies estimated bass to be 37.44 kg/ha. Individual population studies had wide variation in kg/ha of bass; therefore, a few studies may not yield valid data. In contrast, Swingle's balance ratios derived from rotenone samples indicated the lake to be rather stable, with a shift from overcrowded predator fish toward a more balanced condition in 1978 (Table 4).

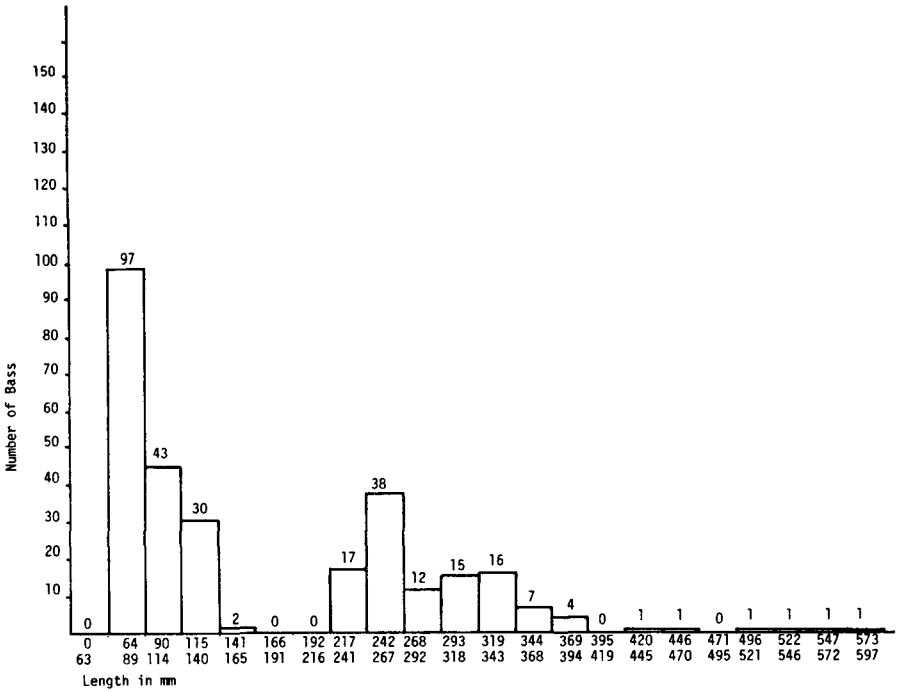

Fig. 2. Largemouth bass length-frequency in mm from rotenone samples 1977, 287 bass.

The lake, when drained, was highly overcrowded with predator fish. The erroneous balance values can be explained by the high population of spotted gar (*Lepisosteus oculatus*) missed in the population studies. Considering the error associated with the gar, Swingle's ratios of balance are fairly accurate.

Although rotenone samples indicated few gar, gill nets captured numerous gar. Channel catfish (*Ictalurus punctatus*) and creek chubsuckers (*Erimyzon oblongus*) were frequently captured in gill nets but infrequently taken in rotenone samples. The gill nets captured 10 of 19 species occurring in the lake. Species not captured were minnows and sunfish too small to become entangled in the 3.8 and 5 cm netting.

CONCLUSIONS

Seine checks were sufficient to determine population balance. The 4.6 m seine was more accurate than the 15.2 m seine.

The number of bass captured upon draining was well within the confidence intervals found by mark and recapture estimate. The data were difficult to evaluate because of fish growth and mortality occurring in the 6-month period from tagging to draining. Angler exploitation information is apparently poor, due to the angler's failure to report recapture of tagged fish.

The PSD index, as determined by rotenone sample length-frequency data, appears stable and useful but lower than the actual value found upon draining. Rotenone population studies varied greatly in estimates of standing crop. One or 2 studies are not sufficient to yield a valid estimate of standing crop. Swingle's balance ratios determined from rotenone samples are fairly stable and appear to provide useful data.

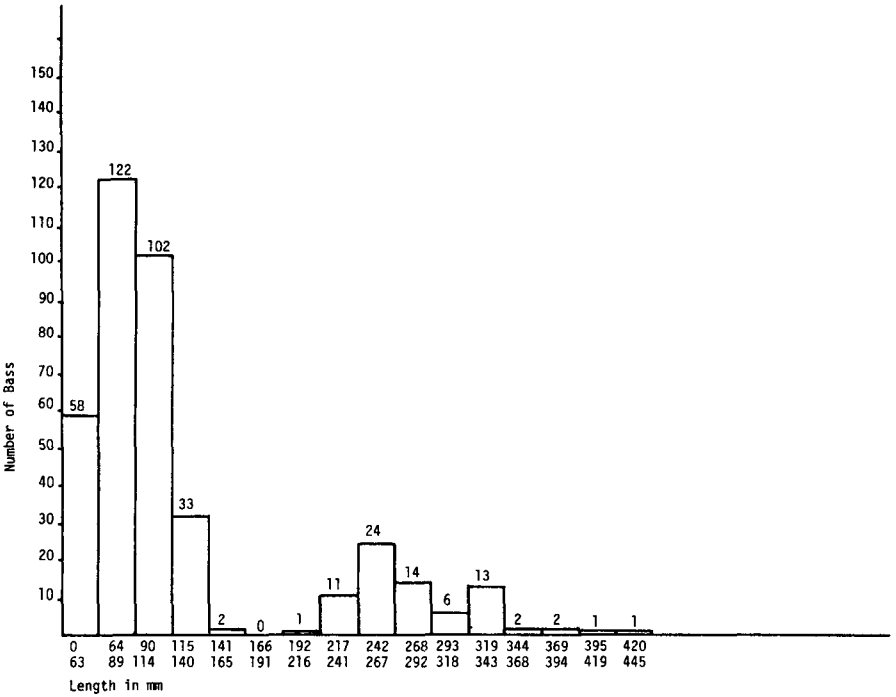

Fig. 3. Largemouth bass length-frequency in mm from rotenone samples 1978, 392 bass.

TABLE 2. Average standing crop of Lake Columbia, 1976-1978 as determined by rotenone samples, kg/ha.

1976 - Two studies	90.84 kg/ha
1977 - Two studies	193.07 kg/ha
1978 - Two studies	187.96 kg/ha
Average for 3 years	157.29 kg/ha
Actual standing crop upon draining, October, 1978	150.67 kg/ha

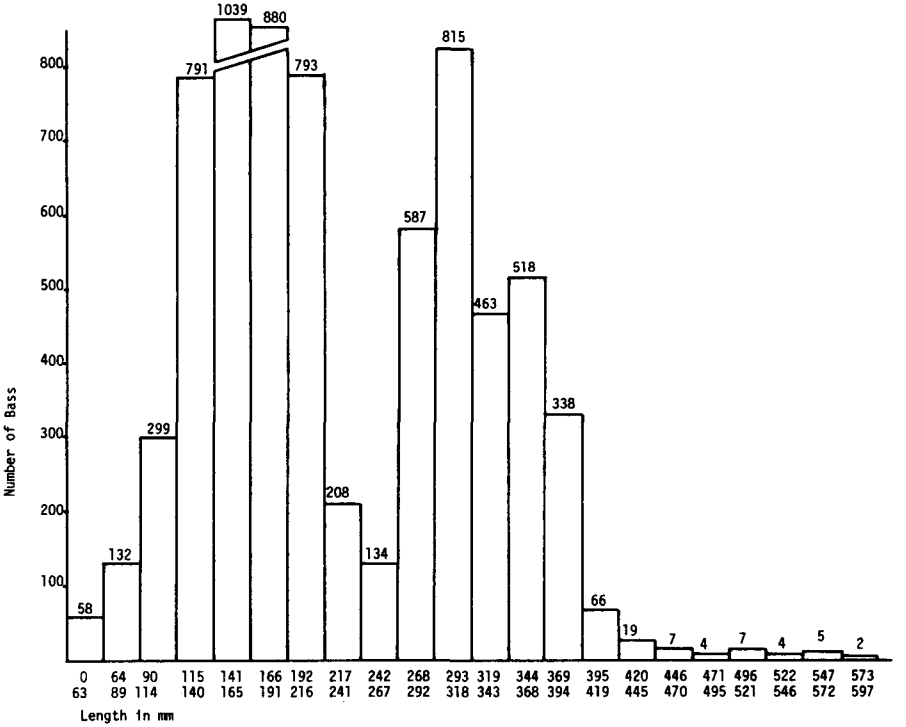

Fig. 4. Largemouth bass length-frequency in mm from rotenone samples, netting and drainage during October 1978, 7, 169 bass.

TABLE 3. Columbia Population Data by Gill Netting, Draining and Rotenoning, July ¬October, 1978.

Size Class (mm)	Golden Shiner No.	Golden Shiner Wt. kg	Yellow Bullhead No.	Yellow Bullhead Wt. kg	Channel Catfish No.	Channel Catfish Wt. kg	Spotted Gar No.	Spotted Gar Wt. kg
0-63	4	0.01			2	T		
-114	6141	33.76	8	0.07	3	0.02		
-165	370	4.81	9	0.23				
-216	135	5.07	1	0.07			1	0.01
-267			8	1.32				
-318			9	2.04			6	0.91
-368			1	0.36			22	3.33
-419					3	2.73	33	6.01
-470					2	2.73	465	148.52
-521					26	43.77	1272	549.70
-572					42	88.63	492	264.36
-622					37	107.41	131	109.13
-699					5	17.09	31	30.09
-749					9	36.81	8	9.91
-800					1	4.00	5	7.00
-851							4	7.73
-902							6	15.90
-953							2	6.41
-1003							1	3.59
TOTALS	6650	43.65	36	4.09	130	303.19	2459	1162.59

Largemouth Bass No.	Largemouth Bass Wt. kg	Bluegill No.	Bluegill Wt. kg	Redear No.	Redear Wt. kg	Warmouth No.	Warmouth Wt. kg
58	0.06	522651	278.98	3946	9.52	4273	5.52
431	3.54	46815	298.43	1292	9.01	2359	22.00
1830	52.92	9313	310.02	418	17.72	881	48.03
1673	154.69	1798	242.82	186	25.36	857	125.28
342	58.42	1817	522.05	162	44.29	103	25.02
1402	503.81			69	31.63		
981	607.03						
404	308.64						
26	34.09						
11	21.32						
9	24.72						
2	5.91						
7169	1775.15	582394	1652.30	6071	173.55	8473	225.85

Spotted Sucker No.	Spotted Sucker Wt. kg	Chain Pickerel No.	Chain Pickerel Wt. kg	Aberrum Gar No.	Aberrum Gar Wt. kg	Creek Chubsucker No.	Creek Chubsucker Wt. kg
		1	T				
		2	0.06			1	0.02
		1	0.03			17	1.47
		2	0.23	1	0.05	103	20.87
1	0.27			4	0.21	233	84.16
6	2.28	7	5.42			17	0.86
4	2.91	4	2.59	1	0.08		
10	6.18	5	3.09	2	0.18		
15	27.14	2	2.00	3	0.61		
1	2.05	2	1.59	2	0.31		
1	3.23						
38	44.06	26	15.01	13	1.24	371	115.40

TABLE 4. Swingle's ratios of rotenone samples, 1976-1978, Lake Columbia.

	F/C	Y/C	AT	A_F	S_F	kg/ha
Shoreline, 1976	1.15**	0.42**	42.21*	29.61'	36.65*	69.16
Cove, 1976	1.63**	0.41**	58.28*	52.10*	25.22*	119.76
Shoreline, 1977	1.21**	0.33**	72.62*	67.72*	27.04*	219.90
Cove, 1977	2.01*	0.24**	79.41*	77.35*	13.04	157.34
Shoreline, 1978	4.37*	1.56*	44.82*	30.21'	35.62*	116.73
Cove, 1978	3.63*	0.98**	47.51*	37.78*	26.92*	282.74
Upon draining	0.69**	0.09**	70.73*	59.48*	13.48	150.67

* balanced
** overcrowded "C"
' inefficient

Finally, gill nets captured the large species present and provided useful information on several species not adequately represented in rotenone samples.

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