ESTIMATION OF BASS NUMBERS IN A FARM POND PRIOR TO DRAINING WITH ELECTRO-SHOCKING AND ANGLING

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ABSTRACT

The number of largemouth bass (*Micropterus salmoides*) in a 3.5-acre experimental pond located at Auburn University Agricultural Experiment Station was estimated by mark and recovery techniques using both Schnabel and Peterson methods. Sampling was done with both electric shocker and angling. Estimates were made during two periods in 1962.

Various estimates of the number of bass made in this study were fairly uniform. However, on draining the estimates were found to be in error by approximately 50 percent.

Based on number of bass recovered at draining and the computed percentage of survival, the value of N for the first period (May 23, to December 20, 1962), was computed to be 604 bass, whereas the Schnabel and Peterson methods gave N values of 304 bass and 469 bass with percent errors of -49.7 and -22.4, respectively. The theoretical requirements of both methods seemed to be met for the first period.

The value of N for the second period (August 1 to December 20, 1962) was computed to be 500 bass, whereas the Schnabel and Peterson methods gave N values of 381 bass and 313 bass with percent errors of -23.8 and 37.4, respectively. The requirements of no mortality for the Schnabel method was violated without any apparent loss of accuracy.

Only with the Peterson method during the first period were the criteria of Robson and Regier (1964) satisfied for censuses with management applications. None of the censuses met their criteria for censuses with research applications.

INTRODUCTION

The reported study was undertaken to gain some insight into the problems encountered in making a mark and recovery estimation of the bass (*Micropterus salmoides*) population by both the Peterson and Schnabel methods. This provided opportunity to check the accuracy of these estimates as the pond was drained following the study.

DESCRIPTION OF THE POND

An experimental pond located at Auburn University Agricultural Experiment Station, Auburn, Alabama, and designated as S-9 was used in this study. The pond was 3.5 acres with a shoreline of approximately 575 yards. It was stocked with 2,625 bluegills (*Lepomis macrochirus*) on February 22, 1960, 875 overwintered *Tilapia mossambica* on April 4, 1960, and 350 largemouth bass fingerlings on May 2, 1960. In 1962, 87 Israeli strain of carp (*Cyprinus carpio*) were added.

METHODS

Two methods of sampling were employed, a boat-mounted electric shocker and angling. The electric shocker was powered by a 23OV A.C. Homelite portable generator delivering 180 cycle, 3-phase current

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and with a rated output of 3,000 watts. The shocking device consisted of a 12-foot boom with five hanging electrodes spaced three feet apart and each five feet long as described by Spencer 1963).

The sampling technique consisted of cruising the shoreline with the shocking apparatus at a fairly constant rate of speed in the late afternoons and early mornings. Fish were marked, measured, and released in the same vicinity as captured. Each trip around the pond was considered a separate sample. The pond was visited daily for two days after shocking to see if any fish had died, even though Spencer (1963) found that the shocker caused no mortality among bass.

Angling samples were taken with spinning tackle using artificial lures, except for the last three angling samples when minnows were used for bait. For angling samples, the shoreline was divided into five 115-yard sections; each section was fished by three anglers for equal time intervals (20 minutes). Each trip around the pond was considered a sample.

During the first study period, fish were marked by clipping a rectangular section from the dorsal portion of the caudal fin. In attempting to prevent regeneration of the caudal clip, the vertical cut was made into the fleshy base of the fin. On May 23 and 24, 1962, 108 bass in the 6- to 12-inch groups were marked in this manner during which time an estimate by the Schnabel method was made. After May 24, 1962, no additional bass were marked. All subsequent samples were used for estimates by the Peterson method.

During the second study period, bass were maked by numbered Monel Butt End fish tags (Size No. 7) placed on the lower jaw. From August 1 to October 26, 1962, 26 bass possessing caudal clips were tagged along with 77 bass that had not been clipped previously. Of the 103 bass tagged, 88 also had the right pelvic fin removed to provide an estimate of tag loss. Only bass of the 8-inch group or larger were tagged. All bass (12) smaller than the 8-inch group that were captured had the right pectoral fin removed and were released. An estimate by the Schnabel method was made during the second period (August 1, 1962 to October 26, 1962), although the requirement of no mortality was violated. After October 26, 1962, no additional fish were marked and subsequent samples were used to make Peterson estimates.

FORMULAS

The multiple census or Schnabel type with the Chapman correction (Ricker, 1958) was used during each period when marking was taking place and is of the form:

$$\hat{N} = \frac{E(C_t M_t)}{R + 1}$$

where,

M_t is the total marked sample at the start of the t th interval

C_t is the total sample taken in the t th interval

R_t is the total recaptures in the sample C_t

R is R_t or total recaptures during the experiment

$\hat{N}$ is the estimated population

After all fish were marked during each of the two marking periods, the subsequent sampling was used to compute population estimations by Bailey's form of the Peterson method (Ricker, 1958), which is given below:

$$\hat{N} = M \frac{(C + 1)}{R + 1}$$

where,

M is the number of fish marked

C is the catch or sample taken forcensus

R is the number of recaptures marked in the sample

$\hat{N}$ is the estimate of the population

COMPUTATION OF N FOR THE FIRST PERIOD

On December 20, 1962, S-9 was drained and all fish were removed. The bass were measured, weighed, and examined for marks or tags. A total of 392 bass was recovered. These were in the inch-groups six to 18, with 16 bass being smaller than 8-inch group. The 16 bass were eliminated from the population under study since the bass marked with caudal clips were in the 6-inch group or larger at marking (May 23 and 24, 1962) and in the 8-inch group or larger at draining (December 20, 1962) (Figure 1). It was likely that none of the 1962 bass year-class could attain a size of larger than the 7-inch group, therefore, by eliminating the 16 bass smaller than the 8-inch group as total recruitment, the population under study was reduced to 376 bass at draining plus 21 bass removed by angling just prior to draining or

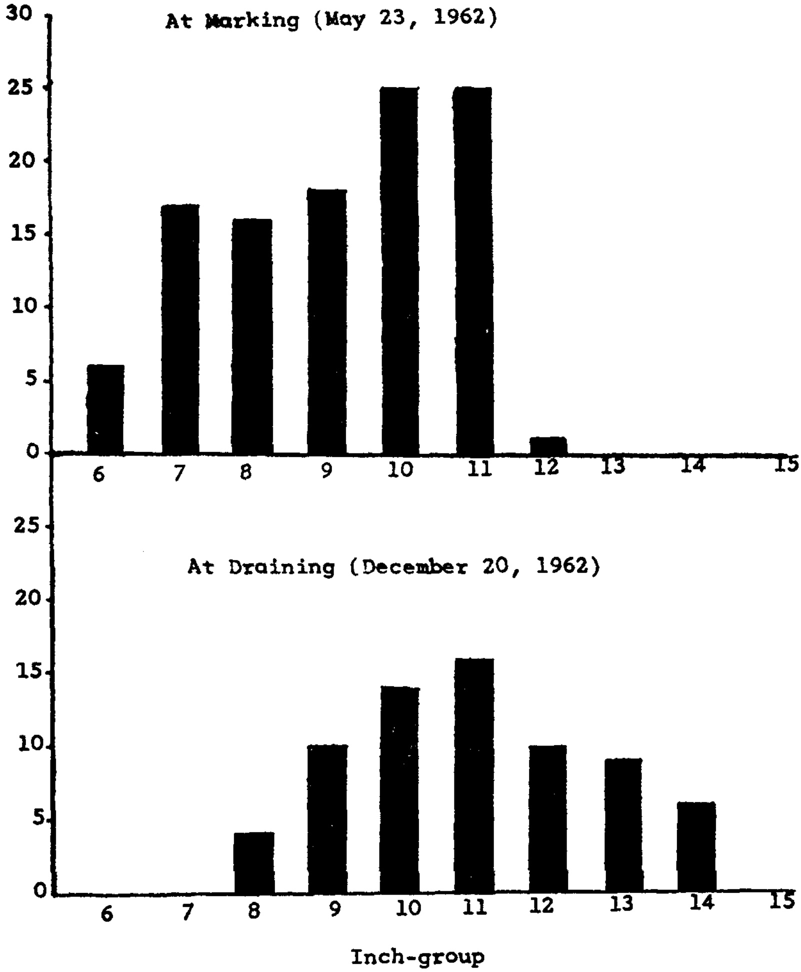

Figure 1. Number of bass of each inch-group marked by caudal fin clips present in S-9 at marking (May 23, 1962) and at draining December 20, 1962)

397 bass. None of the 12 bass smaller than the 8-inch group that had been marked by removal of the right pectoral fin was recovered on draining.

Of the 108 bass marked with caudal clips, 69 bass were recovered on draining. In addition, two bass with caudal clips were removed from the population by angling just prior to draining. This made a total of 71 recoveries of the 108 marked, assuming no regeneration of clips, and a survival of 65.7 percent.

There was no evidence that regeneration occurred in the interval between marking and draining. This assumption was based on the recovery of 18 bass of the 26 marked with both numbered tags and caudal clips. All 18 bass had retained their clips, although one bass showed some regeneration, it was not complete and the regrown rays were obviously deformed.

By assuming the same mortality rate for marked and unmarked fish, the population of six-inch group or larger bass present in S-9 at the time of marking was computed to be 604, i.e., 397/65.7%=604.

Estimation of Number of Bass By Schnabel Method for First Period

The requirements of the Schnabel method seemed to be met: (1) recruitment was eliminated; (2) there appeared to be no loss of marks; (3) all marks were recognized and reported since only biologists worked on the project; (4) the marked fish should have been randomly distributed (if they were to begin with) as they were returned to the water within two minutes of capture; (5) comparison of the successive catches (Table 1) made it appear that perhaps the vulnerability declined with contact with the electric shocker, even though the second day (May 24, 1962) catch remained relatively stable; (6) there was no mortality during the experiment or negligible mortality as the experiment was completed within two days.

Table 1 presents the results of the estimate by the Schnabel method and percent errors. The final estimate (N=304 bass) varied from N by —49.7 percent. The confidence limits computed from the binomial distribution were 195 (304) 502 at the 95 percent probability level. Neither confidence interval included N.

Estimation of Number of Bass by Peterson Method for First Period

Table 2 presents population estimations made by the Peterson census for each individual sample and a cumulative sample for bass marked with caudal clips.

The cumulative sample gave a value of N equal to 469 bass, which differed from N by —22.4 percent. The confidence limits for N computed from the bionomial distribution were 364(469)626 at the 95 percent probability level which included N (604).

The requirements for the Peterson methods are the same as given for the Schnabel method with the exception of item (6). The Peterson method requires that the rate of mortality be the same for marked and unmarked fish. There was no reason to believe that differential mortality existed in this experiment.

There was some evidence that perhaps the marked and unmarked fish were not equally vulnerable to the electric shocker. Since the estimates constantly under-estimated N, it appeared that the marked fish were more vulnerable to both shocking and angling than unmarked fish.

Robson and Reigier (1964) have suggested that the product of the two sample sizes M and C must exceed four times the population size N before a Peterson estimate is valid. The product of M (108) and C (229) from Table 3 is equal to 40.94N.

Using Figure 5 from Robson and Regier (1964) any by reversing the x-and y-axis as suggested by the authors, one finds that an approximate sample size, C, of 210 would be necessary for a 95 percent confidence that the N error will not exceed 25 percent, where M=108 and N=604. In this case (Table 2), C equalled 229 and the percent error of N was —22.4. This level of precision (0.95) and accuracy (0.25) was suggested by Robson and Regier (1964) for censuses with management applications. For censuses with research applications, they suggested levels of precision of 0.95 and accuracy of 0.10. These levels require a

C of approximately 425 (Figure 6 from Robson and Regier, 1964), for M=108 and N=604. These values appeared to be impractical since 425 bass represented 70.4 percent of the total population. However, as these authors point out, the same levels of accuracy and precision could easily be obtained by merely marking 425 bass (70.4 percent of N) and then capturing 108 bass (17.9 percent of N).

Table 1. Estimation of the number of bass by the Schnabel method for the first period

t	C_t	Fish	M_t	C_tM_t	(C_tM_t)	R_t	R+1	N	N	Percentage
23 May (1)*	43	43	—	—	—	—	—	—	604	—
23 May (2)	28	25	43	1204	1204	3	4	301	604	—50.2
24 May (1)	11	7	68	748	1952	4	8	244	604	—59.6
24 May (2)	15	12	75	1125	3077	3	11	280	604	—53.6
24 May (3)	12	10	87	1044	4121	2	13	317	604	—47.5
24 May (4)	17	11	97	1649	5770	6	19	304	604	—49.7
Total	126	108	108			18				

* Number in parentheses refers to the sample numbers.

Table 2. Estimation of number of bass by the Peterson method for the First Period.

Date	Trip	Method	C	M	R	N	N	Percent
June 20	1	Angling	65	108	19	356	604	—41.4
August 1	1	Electricity	9	108	2	360	604	—40.4
August 1	2	Electricity	5	108	1	324	604	—46.4
August 1	3	Electricity	4	108	1	260	604	—55.3
August 1	4	Electricity	4	108	1	270	604	—55.3
August 1	5	Electricity	5	108	2	216	604	—64.2
August 1	6	Electricity	6	108	2	216	604	—64.2
August 11	1	Electricity	8	108	3	243	604	—59.8
August 11	2	Electricity	7	108	1	432	604	—28.5
August 12	1	Angling	21	108	7	297	604	—50.8
September 28	1	Angling	25	108	4	562	604	— 7.0
October 25	1	Angling	6	108	2	378	604	—37.4
October 26	1	Electricity	2	108	0	—	604	—
October 26	2	Electricity	3	108	0	—	604	—
October 26	3	Electricity	15	108	1	864	604	+43.0
November 5	1	Angling	5	108	1	324	604	—46.4
November 8	1	Electricity	1	108	0	—	604	—
November 16	1	Angling	22	108	2	828	604	+37.1
November 29	1	Angling	7	108	1	432	604	—28.5
December 2	1	Angling	5	108	2	216	604	—64.2
December 9	1	Angling	5	108	0	—	604	—
Cumulative	21		229	108	52	469	604	—22.4

An average of 1.5 man-days was required per sample date for angling samples and an average of 2.0 man-days for each shocking sample date; therefore, 4.0 man-days were required to mark the 108 bass and 21.5 man-days were required for the subsequent samples. This was a total of 23.5 man-days required to estimate the bass population of a 3.5-acre farm pond within 22.4 percent of N. However, the man-days could have been decreased by marking a higher percentage of the population, as Robson and Regier (1964) pointed out, "an equal division of resources between catching-marking and catching-examining is optimal."

COMPUTATION OF N FOR THE SECOND PERIOD

The 16 bass smaller than the eight-inch group that were recovered on draining were also deleted in the computation of N for the second period (August 1, 1962 to December 20, 1962). This was done because no bass smaller than the eight-inch group were tagged. Data in Table 3 show that very little growth occurred among the tagged fish from time the bass were tagged (August 1, 1962 to October 26, 1962) until draining (December 20, 1962); therefore, the bass smaller than the eight-inch group had little chance of being recruited into the population being estimated. The value of N at draining was 397 bass.

Of the 103 bass tagged, one died of injuries incurred while being tagged on August 1, 1962; thus the population of tagged bass at large was reduced to 102. Twenty-four of the bass tagged were not recovered on draining; however, two of these bass had previously lost their tags and had been re-tagged, reducing the loss to 22 bass of the 102 bass. In addition, four bass were recovered on draining that had lost their tags. These plus two bass that previously had lost their tags made six tag losses or 6.8 per cent of the 88 bass with multiple marks (numbered tags and pelvic fin clips). Therefore, it could be assumed that one additional bass without multiple marks that had lost its tag was recovered, reducing the loss to 21 bass or 79.4 per cent survival of tagged fish, assuming no regeneration of pelvic fin clips. Since the fish were marked with numbered tags, it was easily determined that no pelvic fin regeneration had taken place.

Assuming no differential mortality between marked and unmarked bass, the population parameter, N, was computed to be 500 bass i. e. 397/74.4%. Since the marking period extended for 86 days, during which some mortality undoubtly occurred, this value of N was taken to be the population size on the date the median numbered tag was used (No. 56 August 12, 1962). However, on draining, the tagged bass were in much poorer condition than the unmarked or caudal clipped bass, but, since no measure of differential mortality was possible, it was assumed that it did not exist.

ESTIMATION OF NUMBER OF BASS BY SCHNABEL METHOD FOR SECOND PERIOD

In this census some of the requirements of the Schnabel method were violated, although most were met: (1) recruitment was eliminated; (2) there was a loss of marks, but corrections were made for these losses; (3) all marks were recognized; (4) the fish were randomly distributed (again, if they were to begin with); (5) the catch per trip was relatively stable (Table 2) suggesting that no differential vulnerability existed for shocking samples; however, the fish with tags were in much poorer condition at draining, possibly indicating a differential vulnerablity may have existed in the fishing samples; (6) mortality did occur during the experiment which lasted 86 days.

Table 4 presents the population estimate by the Schnabel method and percentage errors. The final estimate (N = 381 bass) varied from

Table 3. Sizes of tagged S-9 bass at marking (August 1, 1962 to October 26, 1962) and at draining (December 20, 1962) and size classes of bass lost.

Inch-group	Number of fish* remaining in the same inch-group	Number of fish growing to next larger inch-group	Number of** mortalities occurring in tagged fish
8	6	—	2
9	4	—	1
10	19	—	3
11	11	3	7
12	19	1	5
13	8	1	2
14	5	—	2
15	2	—	1
16	—	—	—
17	—	—	—
18	—	—	1
Total	74	5	24

* includes 4 bass that had lost their tags
** includes 2 tags for fish that were retagged

Table 4. Estimation of the number of bass by the Schnabel method for the second period.

t*	C_t	Fish Marked	M_t	C_tM_t	$\Sigma(C_tM_t)$	R_t	R+1	N	N	Per cent error
1 August (1)*	9	9	—	—	—	—	—	—	500	—
1 August (2)	5	3	9	45	45	2	3	15	500	—97.0
1 August (3)	4	3	12	48	93	1	4	23	500	—95.4
1 August (4)	3	3	15	45	138	0	4	34	500	—93.2
1 August (5)	5	5	18	90	228	0	4	57	500	—88.6
1 August (6)	4	4	23	92	320	0	4	80	500	—84.0
11 August (1)	8	6	27	216	536	1	5	107	500	—78.6
11 August (2)	7	7	33	231	767	0	5	153	500	—69.4
12 August (1)	20	19	40	800	1567	1	6	261	500	—47.8
28 Sept. (1)	25	22	59	1475	3042	3	9	338	500	—47.8
25 October (1)	6	6	81	487	3528	0	9	392	500	—21.6
26 October (1)	2	1	87	174	3702	1	10	370	500	—26.0
26 October (2)	3	3	88	264	3966	0	10	397	500	—20.6
26 October (3)	15	11	91	1365	5331	4	14	381	500	—23.8
Total	116	102	102			13				

* Number in parentheses refers to sample number.

Table 5. Estimation of the number of bass by the Peterson method for the second period.

Date	Method of sampling	C	M	R	N	N	Per cent error
November 5	Angling	5	102	0	—	500	—
November 8	Electricity	1	102	1	102	500	—79.6
November 16	Angling	22	102	7	293	500	—41.4
November 29	Angling	7	102	2	272	500	—45.6
December 2	Angling	5	102	1	306	500	—38.8
December 9	Angling	5	102	3	153	500	—69.4
Cumulative		45	102	14	313	500	—37.4

the value of N by —23.8 per cent, whereas the percentage error for N during the first period (Table 1) in which none of the requirements of the method was violated was —49.7 per cent. It would appear from these data that the violation of the requirement of no mortality during the sampling period did not seriously affect accuracy of the Schnabel estimate.

Confidence limits computed from the binomial distribution were 269(381)706 at the 95 percent probability level. This confidence limit included N.

ESTIMATION OF NUMBER OF BASS BY PETERSON METHOD FOR SECOND PERIOD

The requirements of the Peterson method seemed to be met with the possible exception of marking fish in a short interval. Table 5 presents the estimates of the number of bass by the Peterson method for the second period. The cumulative estimate (N = 313 bass) differed from N by —37.4 percent. The product of MC was equal to 9.18N, which indicated bias was negligible (Robson and Regier, 1964).

CONCLUSIONS

The various estimates of the number of bass made in this study were fairly uniform, which tended to create the impression that they were accurately depicting the population size. However, on draining, the estimates were found to be in error by approximately 50 per cent.

The population estimates made in this study failed to meet the criteria set up by Robson and Regier (1964) for research studies, but could be classified as management or preliminary studies. However, to achieve the accuracy necessary for research studies, an almost impossible number of the population must be caught and marked and must be caught and examined.

The electric shocker provided an effective method of capturing bass, but it appeared that possibly the marked fish and unmarked fish might not be equally vulnerable.

The requirement of no mortality during the experiment was violated with the case of the Schnabel method, but did not appear to affect accuracy of the estimate. However, this study was preliminary in nature and a great deal more work needs to be done to test the accuracy and the effects of the violation of requirements of the methods.

The authors believe that a more dependable test of these effects could be made by intensive sampling within a few weeks of draining.

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BIOASSAY OF INDUSTRIAL POLLUTION BY USE OF MASONITE PLATE SAMPLERS POPULATED WITH CHIRONOMIDS

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ABSTRACT

Plate samplers constructed of ⅛-inch thick masonite were used in a bioassay study of water quality in the Black Warrior River near Tuscaloosa, Alabama. The samplers were placed in a fertilized pond and allowed to accumulate a dense population of larval chironomids (Chironomidae) for one month. The samplers were then placed into the river at stations above the outfall of the uppermost industry and below each outfall of four industries. Counts of chironomids on each of the samplers were made after one week and comparisons were made between the average number of organisms on the samplers at stations above the outfalls and the average number at each of the stations downstream from the outfalls.

It appeared that this inexpensive technique of bioassay can be useful in determining the effects of pollution on chironomids.

Today there are more people with more leisure time demanding more clean freshwater for recreation than ever before. There is also an increased demand for more complex industrial goods and, subsequently, more complex waste products are being discharged into our streams and lakes. There exists a great need for rapid and efficient bioassay techniques to determine the effects of these pollutants on the fish and fish food organisms living in the receiving waters.

Hester and Dendy (1962) described a multiple plate sampler constructed of ⅛-inch thick tempered hardboard ("masonite") and its use to determine the abundance of macroinvertebrate organisms in streams. The samplers were placed into streams for periods of from