FACTORS AFFECTING ESTIMATES OF FISHING MORTALITY OF LARGEMOUTH BASS IN A SOUTHEASTERN RESERVOIR

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Abstract: Largemouth bass (*Micropterus salmoides*) were tagged on West Point Reservoir, Alabama-Georgia in 1976-1978 to estimate rates of fishing. During the 3 years, several factors affecting these estimates were evaluated. Non-response by anglers who recovered non-reward tags was calculated to be 0.66; tag loss was estimated to occur at an average rate of 4% per week; tagging mortality and displacement of fish while tagging did not appear to affect estimates of fishing mortality.

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The extent to which fishing mortality contributes to total mortality in a fish population is of particular interest to fishery managers. Restricted harvest of largemouth bass, for example, can produce angling benefits through increased bass production (Anderson 1972) and greater average size in the creel of other species that bass normally prey upon (Swingle 1967).

Numerous tagging studies have been conducted with largemouth bass on Southeastern reservoirs. Estimates of exploitation have ranged from 3.2% in the St. Johns River, Florida (Moody 1960) to 41.6% on Wautauga Reservoir, Tennessee (Chance 1955). Harvest estimates as high as 64% have been reported from California waters (Rawstron and Hashagen 1972). However, it is often difficult to compare data from different studies as they are confounded by such factors as non-reporting of tagged fish by anglers, tagging mortality, tag loss, and differential vulnerability of tagged fish to fishing.

During 1976-78 a tagging program was conducted on West Point Reservoir to provide estimates of fishing mortality on the largemouth bass population. The purpose of this paper is to assess the effects of various types of rewards, tagging mortality, tag loss, and displacement of fish while tagging on the rates of fishing.

MATERIALS AND METHODS

West Point Reservoir, impounded in 1975, is a 10,500-ha multipurpose reservoir located on the Alabama-Georgia border. Its physicochemical and biological characteristics were given by Davies et al. (1979).

Largemouth bass were collected for tagging using a boat-mounted, 230-V Homelite generator. Pulsed direct current was employed at voltages varying between 200 and 350. About 1,400 fish longer than 255 mm (total length) were tagged in the reservoir from March to June each year. Spaghetti tags (Floy FT-4, lock-on) were inserted with an applicator needle just below the soft dorsal so as to pass through the pterygiophores. Tags were consecutively numbered and bore the inscription "Auburn University". Each year posters were placed at all boat landings as well as at local stores and bait shops informing the public of the reward system (if any) and where to send reports of captured tagged fish.

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Pond studies were conducted in 0.1-ha rectangular ponds (maximum depth, 1.5m) located on the Auburn University Fisheries Research Unit.

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Monetary Reward Systems

In 1976 fish were tagged with orange or white tags. No monetary reward was offered for return of these tags, but each fisherman did receive a letter giving details about the study and information on the locality and date of release of the fish. In 1977 a reward system was incorporated into the program. Three sets of color-coded tags were used. White tags served as a control and offered no monetary reward; blue tags carried a $5 reward; and red tags varied in value from nothing to $500. Values of the red tags were randomly assigned: 100 were worth $5 , four were worth $50 and one was worth $500. In 1978 red and blue tags were utilized; both colors carried a fixed reward of $10.

Each year the program was highly publicized by the local news media. In addition, project personnel promoted the program by giving talks to sportsmen's clubs, church groups, and other civic organizations within a 160-km radius of the reservoir.

Displacement of Tagged Fish

During the first 2 years of the study, largemouth bass were collected by electrofishing and held in a live well until 15-20 fish had been accumulated. Fish were then tagged and released at 1 location. Individual fish may have been displaced 2 km or more from the original point of capture.

Konstantinov (1977) suggested that tagging and the attendant handling may cause fish to deviate from their normal behavior pattern for a period of days or weeks immediately after they are tagged, rendering them more vulnerable to fishing gear and causing an inflated estimate of exploitation. We suspected that by displacing and concentrating the fish we may have enhanced this phenomenon. The 1978 study was designed to determine whether bias was introduced by displacing the fish. Fish in 1 group were tagged with blue tags and released intermittently as in the previous 2 years. Another group was tagged with red tags but were released immediately to minimize displacement. To maintain an even distribution of the 2 methods, fish were alternately released immediately and accumulated in the live well. About 700 fish were tagged by each of the 2 methods.

Tagging Mortality

Thirty-eight largemouth bass were electrofished from bass-bluegill ponds and stocked into two 0.1-ha experimental ponds (22 in 1 pond and 16 in the other). Of the fish stocked in each pond, half were tagged as in the reservoir operation and half were fin-clipped. Bluegills (*Lepomis macrochirus*) were stocked to provide prey. One pond was drained after 11 weeks and the other after 14 weeks, and survival of fish bearing the 2 types of marks was determined.

Tag Loss

Largemouth bass were collected by seining and 25 were stocked into each of two 0.1-ha ponds. Fathead minnows (*Pimephales promelas*), green sunfish (*Lepomis cyanellus*), and bluegills provided prey; grass carp (*Ctenopharyngodon idella*) were stocked for weed control. All bass were tagged as in the reservoir operation. Ponds were seined at weekly intervals and the percentage of tagged bass in the samples were recorded. the fish were not handled while confined by the seine. After 26 weeks the ponds were drained to determine the percentage of bass that had retained their tags. Rate of tag loss was estimated by regressing the natural log of percentage tag retention on time.

RESULTS AND DISCUSSION

Monetary Reward systems

Since estimates of fishing mortality based on tagging typically depend on anglers for tag returns, some stimulus is required to promote their cooperation. Rawstron (1971) estimated non-response for recaptured largemouth bass to be 0.46 assuming 100% return of $5 tags. Coomer (1976) also estimated non-response to be 0.46 for largemouth bass by comparing return of non-reward tags with the return of tags worth $5, $10 and $15. A summary of tag returns is given in Table 1. Only those fish that were recaptured within 1 year of release were considered in our analysis.

In 1976, when no reward was offered, only 78 of 1,351 tags (6%) were returned. Orange tags were returned at a slightly higher rate than white tags, 7% compared to 5% (Table 1). This difference may have been due to chance alone; however, Coomer (1976) suggested that the higher visibility of orange tags, in and out of the water might increase their rate of return. Whatever the case, these values appeared low when compared with creel survey estimates of fishing pressure and catch (Malvestuto et al. 1978).

TABLE 1. Summary of tag returns from largemouth bass released in West Point Reservoir, Alabama-Georgia, 1976-78.

Year of release and tag color	No. fish tagged	Returns (%) First year	Returns (%) by May 1979	Approximate binomial confidence limits
1976				
orange	493	7.3	8.3	5-9
white	858	4.9	5.4	4-6
1977				
white	466	9.9	10.1	7-13
blue	468	16.4	17.3	13-20
red	464	29.1	29.7	25-33
1978				
blue	691	17.5	17.5	14-21
red	688	17.4	17.4	14-21

In 1977 both sets of reward tags were returned at rates significantly higher than the rate for the control (Table 1). Variable-reward returns (red, 29%) were significantly higher than returns from the fixed $5 tags (blue, 16%).

Non-response and the associated variance were calculated as outlined by Chadwick (1968). When compared with red tag returns, non-response of white tags was computed to be 0.66 (95% confidence interval, 0.55-0.77). This rate of response is significantly higher than the values obtained by Rawstron (1971) and Coomer (1976) which were based on fixed rewards of lesser value. Non-response to white tags compared to blue tags was determined to be 0.40, not significantly different from values observed elsewhere (Rawstron 1971; Coomer 1976).

A total of 241 of 1,379 tags (17%) were returned in 1978, indicating an apparent 12% reduction in harvest rate when compared with the variable reward results of the previous year. The creel survey indicated a corresponding decrease in fishing effort exerted toward bass during this period (S.P. Malvestuto, personal communication). Since the ratio of effort exerted for bass (h/ha) to the percentage of tags returned was nearly constant for both years (Table 2), we conclude that a $10 reward was as effective as a variable reward in stimulating angler response.

TABLE 2. Ratio of fishing effort exerted for largemouth bass to the percentage of tags returned, West Point Reservoir, Alabama-Georgia, 1977-1978.

Year	Fishing effort for bass (h/ha)	Returns (%)	Ratio (effort:returns)
1977	39.4	29.1	1.35:1
1978	23.9	17.4	1.37:1

An important consideration in determining the most desirable reward system for a given situation may be the associated cost. In 1977, $385 was paid for 77 blue tag returns (16%). The same year, with the variable reward system, $140 was spent for 135 tag returns (29%). No $500 or $50 tags were returned within a year of release, although one $50 tag was honored after 18 months. In 1978, $2,410 was paid for 241 tags and a return rate equally as good as that obtained using a variable reward.

Even though the variable reward system proved to be both an effective and economical means of stimulating angler response, the low probabilities associated with the high rewards caused public relations problems. Despite our efforts to publicize the program accurately, some anglers did not understand the reward system and believed all red tags to be worth $500. They often were disappointed when they learned their tag was worth nothing or only $5. These problems would have to be weighed against the benefits to determine the system best suited to a given situation.

Displacement of Tagged Fish

There was no significant difference in the percentage of displaced (blue) and non-displaced (red) fish reported. First-year returns were virtually identical for the two methods, 17.5% for blue and 17.4% for red (Table 1). Analysis of returns at weekly intervals showed no significant difference in rate of return.

Rawstron (1971) and Kirkland (1962) both indicated that bass were accumulated before tagging as part of their standard tagging procedures. This could be an important point where available manpower or shocking-boat specifications limit the size of the tagging crew. In the present study accumulation and displacement of fish while tagging did not produce biased estimates.

Tagging Mortaility

Largemouth bass collected by electrofishing, tagged with spaghetti tags and held in ponds for 11 or 14 weeks suffered no mortality, but 37% of the tagged fish shed their tags.

These findings concur with those of Kirkland (1962) who found no mortality among largemouth and spotted bass (*M. punctulatus*) that had been shocked, tagged with Petersen disk tags, and held in ponds for 10 days. Our conclusion is that tagging mortality associated with the present methods is negligible.

Tag Loss

The problem of tag loss is widely reported in the literature and appears to be a function of tag type, tag construction, method of application, species of fish used and time. Loss of spaghetti tags in pond situations varied from 30% in 1 year for largemouth bass (Tebo 1956) to 20% in 9.5 weeks for bluegills (Latapie 1967).

During the course of the study 7 tags were found in the experimental ponds. Five had apparently been lost because of faulty construction, 1 had become lodged in a crack in the retaining wall and the fish had pulled free, and 1 was found intact on the pond bottom. Tag failure was caused by the dislodging of the locking device from the vinyl tubing.

Largemouth bass appeared to shed their tags at an average exponential rate of 4% per week. When the natural log of percentage retention was regressed against time in weeks (Fig. 1) a straight line provides a reasonable fit to the data ($R^2 = 0.60$). The slope of this line provides an estimate of instantaneous tag loss; its antilog is weekly tag retention and was calculated to be 0.96.

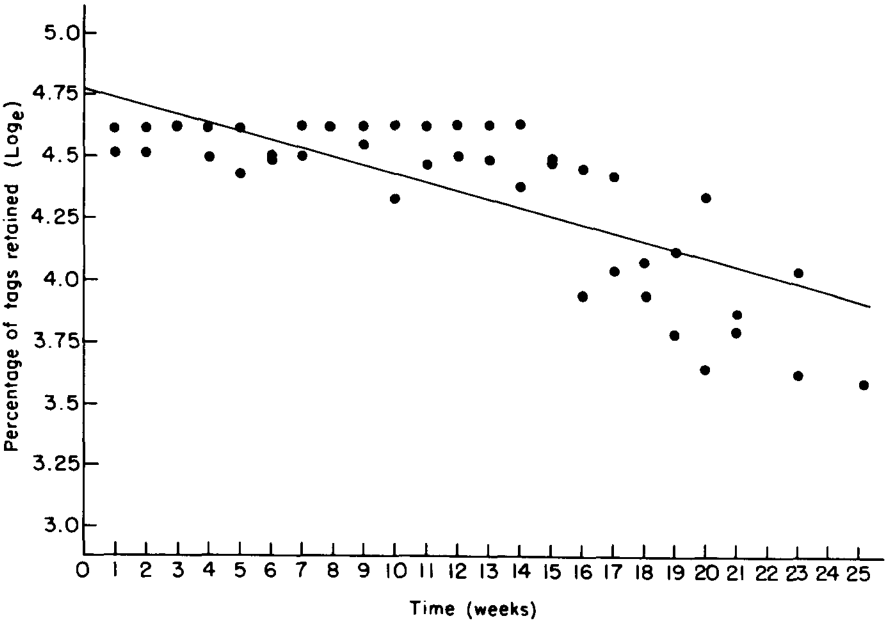

Fig. 1 The natural log of the percentage of tagged fish present in the seine hauls from the pond study regressed against time in weeks provided an average rate of tag loss that was used in adjusting the number of tagged fish present in the reservoir population.

From our observations it appears that conventional means of estimating fishing mortality would tend to underestimate the true value, primarily because of the non-reporting of recaptured tagged fish and/or the loss of tagged fish (loss of marks) from the population. One method of calculating the number of tagged fish remaining in the population at any time during the study period could be based on what might be termed "tag mortality". Regressing the natural log of catch per effort for tagged bass against time in weeks gives an estimate of weekly tag mortality that is composed of fishing and natural mortality and tag loss. The antilog of this value represents "tag survival" and can be used to predict the average number of tagged fish present during each week. Weekly fishing mortality can be calculated from weekly returns. However, the validity of adjusting the number of tagged fish present by "tag mortality" depends largely on the assumption that catchability of largemouth bass remains constant throughout the study period.

LITERATURE CITED

Anderson, R.O. 1972. Influence of mortality rates on production and sustained harvest of largemouth bass populations. Pages 18-28 *in* J.P. Frank, editor. Symposium on overharvest and management of largemouth bass in small impoundments. North Central Division, American Fisheries Society, Special Publication Number 3.

Davies, W.D., W.L. Shelton, D.R. Bayne,and J.M. Lawrence. 1979. Fisheries and limnological studies West Point Reservoir, Alabama-Georgia. Final Report. Phase I. U.S. Army Corps of Engineers. Vicksburg, MS. Technical Report:EL-78-4, TA7, W34. 233 pp.

Chadwick, H.K. 1968. Mortality rates in the California striped bass population. California Fish and Game 54:228-246.

Chance, C.J. 1955. Unusually high tag returns from fish tagging experiments on two TVA reservoirs. J. Wildl. Manage. 19:500.

Coomer, C.E., Jr. 1976. Population dynamics of black bass in Centerhill Reservoir, Tennessee. M.S. thesis, Tennessee Technological University Cookeville, TN.

Kirkland, L. 1962. A tagging experiment on spotted and largemouth bass using an electric shocker and petersen disk tags. Proc. Ann. Conf. Southeastern Assoc. Game and Fish Comm. 16:424-432.

Konstantinov, K.G. 1977. Modern methods of fish tagging. J. Ichthyology 17:924-938.

Latapie, W.R. 1967. Evaluation of various tagging methods on several freshwater and estuarine fishes of Louisiana. Proc. Ann. Conf. Southeastern Assoc. Game and Fish Comm. 21:505-509.

Malvestuto, S.P., W.D. Davies, and W.L. Shelton. 1978. An evalutation of the roving creel survey with non-uniform probability sampling. Trans. Amer. Fisheries Soc. 107:255-262.

Moody, H.L. 1960. Recaptures of adult largemouth bass from the St. Johns River, Florida. Trans. Amer. Fisheries Soc. 89:295-300.

Rawstron, R.R. 1971. Non-reporting of tagged white catfish, largemouth bass, and bluegills by anglers at Folsom Lake, California, California Fish and Game 57:246-252.

Rawstron, R.R., and K. Hashagen, Jr. 1972. Mortality and survival rates of tagged largemouth bass at Merle Collins Reservoir, California. California Fish and Game 58:221-230.

Swingle, H.S. 1967. Warmwater ponds for pan fish. Pages 169-171 *in* Outdoors USA. U.S. Department of Agriculture, Washington D.C.

Tebo, L.B. 1956. Preliminary experiments of the use of spaghetti tags. Proc. Ann. Conf. Southeastern Assoc. Game and Fish Comm. 10:77-80.

A SAS PROGRAM SUMMARIZING DATA COLLECTED BY ROTENONE SAMPLING

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Abstract: A SAS program was designed to compile and summarize data collected by rotenone sampling. The program is designed to accept data in a variety of forms, providing a statistical summary of number, weight and percentage composition for all species and also a separate summary for harvestable gamefish and/or forage fish. Options are available to calculate weights for fish collected on second and third day pickups with weight-length relationships established from first day fish for either individual fish or by size groups.

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According to Hall (1962) rotenone sampling is one of the most preferred methods for obtaining fish population data in all the southeastern states and usually incorporates either cove or blocknet sampling. In many situations rotenone samples provide reliable length frequency data and can be used for accurate standing crop estimates for selected sections of the body of water sampled (Provine 1975).

The quantity of data generated by rotenone sampling requires numerous hours for manual computation and summarization of results for management decisions. Opportunities for computational errors are many when this amount of data is analyzed. This paper describes a SAS program that summarizes, simplifies, and increases the accuracy of data assemblage. The program is designed to accept data in a variety of forms and provide statistical summaries of the number, weight, percentage composition for all species, and summaries for harvestable gamefish and/or forage fish. Weight-length options are available within the program that can be used to calculate weights of second and third day fish. These data can be generated for either individual fish or by size groups. If this option is not desired, data summaries can be obtained when second and third day weights are recorded in the field.

The computer language, SAS, was chosen because of versatility of data manipulation and the availability of wide ranges of easily employed statistical analysis. An inexperienced programmer can quickly utilize SAS programs because the language does not require the user to format output or program summary techniques. Barr et al. (1976) provided a list of institutions which maintain SAS programs and if the user is unfamiliar with SAS, manuals by Helwig (1977, 1978) are suggested as useful introductions. This study was sponsored in part by an Environmental Protection Agency grant R80549 and special funds from the Center for Environmental Programs of the Institute of Food and Agricultural Sciences, University of Florida.

MATERIALS AND METHODS

The following field data are needed: sample location (LAKE), date of rotenone application (DATE), sample number (SAMPLE), day of fish pickup (DAY), species collected (SPECIE), size group (SG), number in the size group (NUMBER), [equals one for an individual fish measured for weight-length], weight of all individuals within a size group or of individual fish (WEIGHT), and length of individual fish (LENGTH) [Line 2, Appendix 1]. This format allows for weight-length calculations for individual fish as well as multiple weight-length calculations for a species size group which can be assembled without prior summarization. A size group must be assigned to individual fish measured for weight-length relationships. The sample location must be entered in the alpha mode.

The program is written to accept data placed in arbitrary fields, thereby simplifying keypunching. The cards require only field data which is punched in the order specified on the input card (Line 2, Appendix 1) with a blank space between each variable. If the weight or length variable is missing, then a decimal point must be entered. Several examples of data cards are given in Fig. 1. the first example is from Orange Lake: 15 June 1979: sample number 21, first day pickup; species code 4; size group 2; 142 fish in the size group; weight 189 g and a value missing for length (represented by the decimal point). the second example depicts a card for an individual fish weighing 1.8 g and 31 mm long. Example 3 represents a second day pickup with 72 fish in the size group where both weight and length values are missing. Example 4 is from Clear Lake; 3 October 1978; sample number 1; second day pickup of species 7; 6 inch size group; with 9 individuals weighing 1.26 pounds; with length eliminated as an input variable. Weights in pounds and ounces cannot be utilized in this program, therefore, they must be converted to decimal pound weights. Length can be eliminated from the input card (Statement 2, Appendix 1, last entry of card) if all individuals collected in the field are pooled into size groups for weighing and counting.

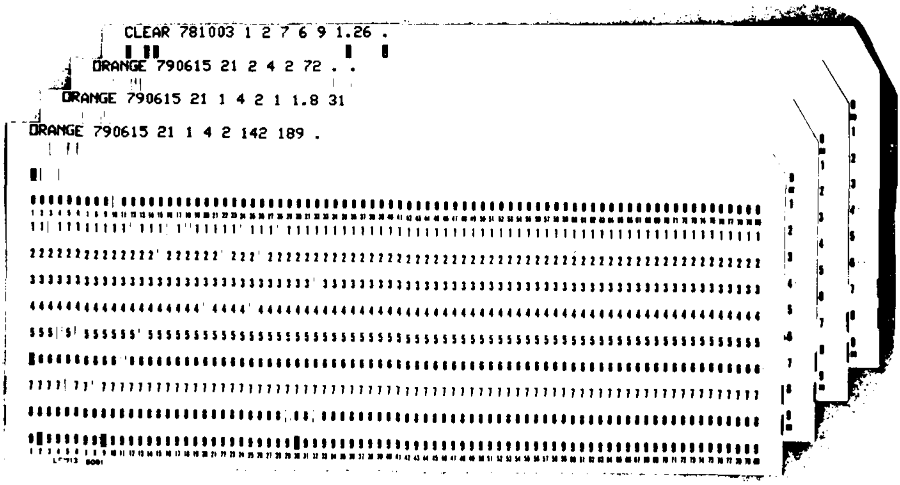

Fig. 1. Examples of data cards for SAS program.

The value assigned a species is a numeric code ranked in increasing phylogenetic order. All known species collected within a sample must be ranked. The first species is assigned number one and each succeeding species the next highest integer. If a new species is encountered later in the study, the new species' phylogenetic rank should be determined and it is given a decimal value between that of the 2 species on either side (Appendix 2). The use of a format statement (Line 5.0 to 5.7, Appendix 1) allows the species name to appear on the computer output rather than the numerical species code.

It is advisable to run only the data for 1 sample location (i.e. lake) at a time unless each rotenone sample is given a consecutive number regardless of sample location.

DISCUSSION

When missing weights are to be computed for second and third day fish, it is important to have weights for all size groups of a species collected on the first day. When a species size group is collected on second or third day and had no weight on the first day, then a substitute weight for the size group must be found. If a weight-length regression from the current data for the species is run at program statements 7 and 8 (Appendix 1), then the size group midpoint-length can be used to determine the missing mean size group weight (XSGWT). The mean size group weight can also be obtained from a previous study of the species or from a source such as the *Handbook of Freshwater Fishery Biology* (Carlander 1969, 1977). IF-THEN statements assigning missing mean size group weights (XSGWT) to those species size groups missing on the first day must be constructed and placed between program statements 17 and 18 (Appendix 1). Appendix 3 demonstrates an IF-THEN statement assigning a species missing mean size group weight. Recording lengths of second and third day fish for which weight-length regressions are not run will cause the use of these IF-THEN statements to have no effect. This is a result of by-passing program statement 20 (Appendix 1), because program statement 19 sends the pointer to statement 21 where the value for PWT is missing. If the lengths are recorded for such species they should be punched as missing values on the data cards.

The program presented in Appendix 1 is designed to calculate second and third day weights from field data which includes individual weight-length measurements from fish collected on the first day. If second and third day weights are missing and all data were size grouped (no individual weight-length data recorded first day), then program statements 7,8,9,17, 19 and 21 should be omitted. Various agencies sort fish collected on second and third day pickups into size groups and then record a second and third day size group weight. Program statements 6 through 25 should then be eliminated.

Program statements 7 to 9 instruct the computer to calculate and print regression statistics for weight-length relationships for species when appropriate data are available (Appendix 2). Error statements of the form "ERROR: CLASS VARIABLES OR ALL DEPENDENT VARIABLES ARE MISSING ON EVERY OBSERVATION" will appear on the printout for every species that was not measured for weight-length purposes. These error statements have no effect and can be ignored. Average size group weights by species are computed by statements 10 through 13 and are printed as instructed by statements 14 and 15. Statements 16 through 25 provide instructions for computation and printing of missing weights. Statements 26 through 30 provide for the sums of numbers and weights by species and size group for each sample. It is advisable to run the first 30 statements prior to final analysis to check for data errors and to insure that all missing weights are computed. After proofing the results the data set (FISH) can be stored.

Once the data have been proofed, the remaining program statements provide for data summary. Statements 31 through 35 provide for printing the total number and weight for each species by size group. Length frequency histograms can be constructed from these data. The data are then summarized by sample, giving total numbers and weights for each species (Statements 36 through 46). If a species was not collected in a sample, the data summarization assigns a zero value for number and weight. Tables, with all samples pooled, giving the mean, standard deviation and percentage composition by number and weight for each species are printed as instructed by statements 47 through 59.

A summary of harvestable gamefish is initiated by statement 60. The reader should refer to Appendix 4 or instructions pertaining to IF--THEN statements for harvestable gamefish. All IF-THEN statements utilized should be inserted at program statement 61.0 The harvestable gamefish data summary (Statements 63 through 85) generates the same type tables as discussed in the preceding paragraphs for all species (program statements 36 through 46, and 47 through 59). The gamefish section can also be utilized for forage fish summarization by replacing the word GAMEFISH with the word FORAGE in program statements 60 through 85. The word HARVEST (program statements 60 through 62) should also be replaced with the word PREY. The other changes needed for forage summary are creation of the IF-THEN statements inserted at program statement

61.0. They follow the fomat outlined in Appendix 4 with the following changes:
IF SPECIE=3 AND SG LE 6 THEN PREY = 1;
IF SPECIE = 4 AND SG LE 6 THEN PREY = 1;
LE represents 'less than or equal to' in the forage summary, while GE stands for 'greater than or equal to' in the harvestable analysis.

The utilization of SAS programs for compilation and analysis of rotenone samples allows the researcher to conduct extensive statistical analysis. Statistical comparisons between years, seasons or locations can be conducted for weight-length regressions or total standing crop by insertion of the proper program statements.

LITERATURE CITED

Barr, A.J., J.H. Goodnight, J.P. Sall and J.T. Helwig. 1976. A Users Guide to SAS 76. Sparks Press, Raleigh, N. Carolina. 329 pp.

Carlander, K.D. 1969. Handbook of freshwater fishery bilogy, Volume 1. Iowa State Univ. Press, Ames, Iowa. 752 pp.

____________. 1977. Handbook of freshwater fishery biology, Volume 2. Iowa State Univ. Press, Ames, Iowa. 431 pp.

Hall, G.E. 1962. A survey of fish population sampling methods in Southern reservoirs. Report to Reservoir Committee, So. Div., Am. Fish. Soc. 16 pp.

Helwig, J.T. 1977. SAS suplemental library users guide. Kingsport Press, Kingsport, Tenn. 171 pp.

____________. 1978. SAS introductory guide. SAS Institute Inc., Raleigh, N. Carolina. 83 pp.

Provine, W.C. 1975. Evaluation of fish collection devices. Texas Parks and Wildl. Dept. D-J Proj. F-31-R-1:14 pp.

Swingle, H.S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Ala. Agr. Expt. Sta. Bull. No. 274. 74 pp.

Appendix 1. SAS program for compilation and analysis of rotenone samples.

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      *PROGRAM PRECEDED BY JOB CONTROL CARDS;
1     DATA FISH;
2     INPUT LAKE $ DATE SAMPLE DAY SPECIE SG NUMBER WEIGHT
      LENGTH;
3     LOGWT=LOG1O (WEIGHT); LOGTL=LOG1O (LENGTH);
4     CARDS;
      *ALL DATA CARDS GO HERE BETWEEN STATEMENT 4 AND THIS
      CARD;
5.0   PROC FORMAT;
5.1   VALUE COMNAME
5.2   1=FLORIDA GAR
5.3   2=GOLDEN SHINER
5.4   3=MOSQUITOFISH
5.5   4=BLUEGILL
5.6   5=LARGEMOUTH BASS
5.7   ;
      *COMPUTING WEIGHT-LENGTH LINES AND PRINTING THE
      REGRESSION STATISTICS;
6     PROC SORT; BY LAKE SPECIE SG LENGTH;
7     PROC GLM; FORMAT SPECIE COMNAME.; BY LAKE SPECIE;
8     MODEL LOGWT=LOGTL; OUTPUT OUT=PREDWT PREDICTED=PWT;
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9   TITLE WEIGHT-LENGTH REGRESSION STATISTICS;
    *COMPUTING AVERAGE SIZE GROUP WEIGHTS;
10  DATA MEANSGWT; SET FISH; IF WEIGHT NE .;
11  PROC MEANS NOPRINT; BY LAKE SPECIE SG; VAR NUMBER WEIGHT;
12  OUTPUT OUT=MEANSGWT SUM=NO WT;
13  DATA MEANSGWT; SET MEANSGWT; XSGWT=WT/NO;
14  PROC PRINT; FORMAT SPECIE COMNAME.;
15  TITLE AVERAGE SIZE GROUP WEIGHTS;
    *COMPUTING MISSING WEIGHTS FOR FISH;
16  DATA FISH; MERGE MEANSGWT FISH; BY LAKE SPECIE SG; DROP NO
    WT;
17  DATA FISH; MERGE PREDWT FISH; BY LAKE SPECIE; PWT=10**PWT;
18  IF WEIGHT NE . THEN GO TO JUMPA;
19  IF WEIGHT NE .THEN GO TO JUMPB;
20  WEIGHT=XSGWT*NUMBER;
21  GO TO JUMPA; JUMPB: WEIGHT=PWT;
22  JUMP A: RETURN;
23  PROC SORT; BY LAKE SPECIE WEIGHT;
24  PROC PRINT; FORMAT SPECIE COMNAME.;
25  TITLE DATA SET WITH COMPUTED MISSING WEIGHTS;
    *SUMMARIZING THE NUMBER AND WEIGHT OF THE DATA BY
    SAMPLE, SPECIE AND SG;
26  PROC SORT; BY LAKE SAMPLE SPECIE SG DATE;
27  PROC MEANS NOPRINT; BY LAKE SAMPLE SPECIE SG DATE; VAR
    NUMBER WEIGHT;
28  OUTPUT OUT=FISH SUM=NUMBER WEIGHT;
29  PROC PRINT; FORMAT SPECIE COMNAME.;
30  TITLE THE NUMBER AND WEIGHT OF FISH FROM EACH SIZE GROUP
    FOR EACH SAMPLE;
    *COMPUTING THE LENGTH FREQUENCY OF FISHES FROM ALL
    SAMPLES;
31  PROC SORT; BY LAKE SPECIE SG;
32  PROC MEANS NOPRINT; BY LAKE SPECIE SG; VAR NUMBER WEIGHT;
33  OUTPUT OUT=LENQFREQ SUM=NUMBER WEIGHT,
34  PROC PRINT; FORMAT SPECIE COMNAME.;
35  TITLE LENGTH FREQUENCY DATA OF FISH FROM ALL SAMPLES;

    *SUMMARIZING THE TOTAL NUMBER AND WEIGHT OF FISHES BY
    SAMPLE;
36  DATA FISHB; SET FISH; WEIGHT=WEIGHT*100;
37  PROC SORT; BY LAKE SAMPLE SPECIE;
38  PROC FREQ;
39  TABLES LAKE*SAMPLE*SPECIE/OUT=A SPARSE NOPRINT; WEIGHT
    NUMBER;
40  DATA A; SET A; NUMBER=COUNT; DROP COUNT PERCENT;
41  PROC FREQ DATA=FISHB;
42  TABLES LAKE*SAMPLE*SPECIE/OUT=B SPARSE NOPRINT; WEIGHT
    WEIGHT;
43  DATA B; SET B; WEIGHT=COUNT; DROP COUNT PERCENT;
44  DATA FISHB; MERGE A B; BY LAKE SAMPLE SPECIE; WEIGHT
    WEIGHT/100;
45  PROC PRINT; FORMAT SPEICE COMNAME.;
46  TITLE TOTAL NUMBER AND WEIGHT OF FISHES BY SAMPLE;
    *SUMMARIZING THE NUMBER, WEIGHT AND PERCENT
```

```
      COMPOSITION OF FISH FOR ALL SAMPLES;
47    PROC SORT; BY LAKE SPECIE;
48    PROC MEANS NOPRINT; BY LAKE SPECIE; VAR NUMBER WEIGHT;
49    OUTPUT OUT=MEANS MEAN=XNO XWT STD=SNO SWT;
50    DATA MEANS; SET MEANS; XWT=XWT*100;
51    PROC FREQ;
52    TABLES SPECIE/OUT=A SPARSE NOPRINT; WEIGHT XNO;
53    DATA A; SET A; PERCENTN=PERCENT; DROP COUNT PERCENT;
54    PROC FREQ DATA=MEANS
55    TABLES SPECIE/OUT=B SPARSE NOPRINT; WEIGHT XWT;
56    DATA B; SET B; PERCENTW=PERCENT; DROP COUNT PERCENT;
57    DATA MEANS; MERGE MEANS A B; BY SPECIE; XWT=XWT/100;
58    PROC PRINT; FORMAT SPECIE COMNAME.;
59    TITLE THE NUMBER, WEIGHT AND PERCENT COMPOSITION OF
      FISHES FOR ALL SAMPLES;
      *SEPARATING HARVESTABLE GAMEFISH FROM THE DATA FOR
      SUMMARIZATION;
60    DATA GAMEFISH; SET FISH; WEIGHT=WEIGHT*100; HARVEST=0;
61.0  IF SPECIE=4 AND SG GE 6 THEN HARVEST=1;
61.1  IF SPECIE=5 AND SG GE 10 THEN HARVEST=1;
62    IF HARVEST NE 1 THEN DELETE;
      *SUMMARIZING THE NUMBER AND WEIGHT OF GAMEFISH BY
      SAMPLE;
63    PROC SORT; BY LAKE SAMPLE SPECIE;
64    PROC FREQ;
65    TABLES LAKE*SAMPLE*SPECIE/OUT=A SPARSE NOPRINT;
      WEIGHT NUMBER;
66    DATA A; SET A; NUMBER=COUNT; DROP COUNT PERCENT;
67    PROC FREQ DATA=GAMEFISH;
68    TABLES LAKE*SAMPLE*SPECIE/OUT=B SPARSE NOPRINT;
      WEIGHT WEIGHT;
69    DATA B; SET B; WEIGHT=COUNT; DROP COUNT PERCENT;
70    DATA GAMEFISH; MERGE A B; BY LAKE SAMPLE SPECIE;
      WEIGHT=WEIGHT/100;
71    PROC PRINT; FORMAT SPECIE COMNAME.;
72    TITLE THE NUMBER AND WEIGHT OF GAMEFISH BY SAMPLE;
      *SUMMARIZING NUMBER, WEIGHT AND PERCENT COMPOSITION
      OF GAMEFISH FOR ALL SAMPLES;
73    PROC SORT; BY LAKE SPECIE;
74    PROC MEANS NOPRINT; BY LAKE SPECIE; VAR NUMBER WEIGHT;
75    OUTPUT OUT=MEANS MEAN=XNO XWT STD=SNO SWT;
76    DATA MEANS; SET MEANS; XWT=XWT*100;
77    PROC FREQ;
78    TABLES LAKE*SPECIE/OUT=A SPARSE NOPRINT; WEIGHT XNO;
79    DATA A; SET A; PERCENTN=PERCENT; DROP COUNT PERCENT;
80    PROC FREQ DATA=MEANS;
81    TABLES LAKE*SPECIE/OUT=B SPARSE NOPRINT; WEIGHT XWT;
82    DATA B; SET B; PERCENTW=PERCENT; DROP COUNT PERCENT;
83    DATA MEANS; MERGE MEANS A B; BY LAKE SPECIE;
84    PROC PRINT; FORMAT SPECIE COMNAME.;
85    TITLE THE NUMBER, WEIGHT AND PERCENT COMPOSITION OF
      GAMEFISH FOR ALL SAMPLES;
      *END OF JOB CARD FOLLOWS:
```

The program statement numbers should not be punched on cards. They are included here for reference purposes. Each program statement represents one computer card.

Appendix 2. Numeric code for species identification.

PROC FORMAT; VALUE COMNAME	PROC FORMAT; VALUE SCINAME
1 =FLORIDA GAR	1 =LEPISOSTEUS PLAYTYRHINCUS
2 =BOWFIN	2 =AMIA CALVA
3 =GIZZARD SHAD	3 =DOROSOMA CEPEDIANUM
4 =GOLDEN SHINER	4 =NOTEMIGONUS CRYSOLEUCAS
4.1=TAILLIGHT SHINER	4.1 =NOTROPIS MACULATUS
5 =LAKE CHUBSUCKER	5 =ERIMYZON SUCETTA
6 =MOSQUITOFISH	6 =GAMBUSIA AFFINIS
7 =BLUEGILL	7 =LEPOMIS MACROCHIRUS
8 =REDEAR	8 =LEPOMIS MICROLOPHUS
9 =LARGEMOUTH BASS	9 =MICROPTERUS SALMOIDES
10 =BLACK CRAPPIE	10 =POMOXIS NIGROMACULATUS

Two examples of procedure FORMAT in which the species code ranks fish phylogenetically. The species code 4.1 representing taillight shiner was inserted after the original ranking was made. This section is represented by statements 5.0 through 5.7 in Appendix (1).

Appendix 3. IF-THEN statements assigning a missing specie size group weight.

```
IF SPECIE=4 AND SG=2 THEN XSGWT=8;
```

An example of an IF-THEN statement assigning 8 grams as a mean size group weight (SXGWT) for specie 4 in size group (SG) 2. As many statments as are needed can be used for different species size groups. These IF-THEN statements should be inserted between program statements 17 and 18.

Appendix 4. IF-THEN statements for harvestable fish analysis.

```
IF- SPECIE= 7 AND SG GE 6 THEN HARVEST=1;
IF SPECIE= 8 AND SG GE 6 THEN HARVEST=1;
IF SPECIE= 9 AND SG GE 10 THEN HARVEST= 1;
IF SPECIE=10 AND SG GE 9 THEN HARVEST=1;
```

The size groups (SG) represent Swingle's (1950) minimum harvestable inch groups for the game fish coded in Appendix 2. The user can insert any predetermined size group after the GE statement selected. the number of cards will vary with the users needs. This section is represented by statements 61.0 and 61.1 in Appendix 1.