IMPLICATIONS FROM THE OKLAHOMA STATE LAKE CREEL SURVEY TO IMPROVE CREEL SURVEY DESIGN

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INTRODUCTION

In much of sport fishery management the desired goal is maximum satisfaction of the fishermen. This may be considered in terms of total harvest, harvest of particular species, and catch per unit effort. An adequate measurement of these quantities can only be obtained in most cases by a well designed sample survey of the fishermen.

Characteristics of the fishermen and the fishery need to be critically examined in order to design creel surveys with maximum effectiveness. In designing creel surveys, the most common procedure is to stratify by weekend and weekday periods. Within these strata it is necessary to consider whether further breakdown into categories such as days of the week and periods of the day is desirable. In order to determine the proper estimation and sampling procedures to use in obtaining a catch per unit effort, it is useful to have some knowledge of the relationship between catch rates and other fishery statistics. Finally, the problem of handling missing data is critical in deciding on the estimation procedures. This paper presents an evaluation of information relative to the above items collected during a year-long (December 1964 to December 1965) creel survey of lakes owned by the Oklahoma Department of Wildlife Conservation. This evaluation was intended to provide a basis for improved survey design for similar small lakes ranging in size from 20 to 200 acres. The implications of these findings for creel surveys generally, with particular emphasis on the estimation of catch rates, are discussed. A more detailed presentation of these findings is given by Brown (1969).

CREEL SURVEY STATISTICS

The sampling design for the survey was developed by Victor Lambou, then Director of the research unit of the Oklahoma Department of Wildlife Conservation, the Oklahoma Fishery Research Laboratory. It was a stratified random sampling design with samples drawn without replacement. One morning and one afternoon sample was chosen each weekday and each weekend. The survey was supervised by the Regional Fishery Biologists. Part-time employees were hired to interview fishermen. The author directed the estimation of the desired statistics. A description of this survey and the estimates made have been reported by Jarman et al. (1968) and Brown (1969).

On ten of the twelve lakes, information was gathered from fishermen at the econclusion of the fishing trip. The information from these lakes (Table 1) provided the data for the analysis in the present study.

Total pounds of fish of all species harvested ranged from 22 to 107 per acre, with most lakes having 40 to 60 pounds per acre. The number of fish per acre varied from 68 to 242. The man-hours per acre ranged from 138 to 622.

Bass and catfish comprised the largest portion of the weight of the catch in these lakes. Virtually, all bass were largemouth bass *(Micropterus salmoides)* while both black bullheads *(Ictalurus melas)* and channel catfish *(Ictalurus*

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punctatus) were included in the catfish class. In all lakes channel catfish were more numerous than bullheads. The sunfish harvested were bluegill *(Lepomis macrochirus),* redear *(Lepomis microlophus)* and green sunfish *(Lepomis cyanellus).* White crappie *(Pomoxis annularis)* and a very few black crappie *(Pomoxis nigromaculatus)* were represented in the harvest.

The majority of both the harvest and fishing pressure occurred from April through October. Crappie harvest was highest in May and poorer during the summer. Bass harvest was largest throughout the summer months and smallest from December through March. Most catfish were harvested during the summer and early fall, while sunfish harvest was heaviest in the spring and early summer. Oklahoma fishermen, when fishing state-owned lakes, usually went in parties of two or three and fished approximately three hours.

Throughout this discussion the term significant difference refers to a difference judged to be significant at the 0.05 probability level. Unreferenced statistical methods follow Steel and Torrie (1960) and Cochran (1963).

COMPARISON BETWEEN WEEKDAY AND WEEKEND VALUES

In creel studies designed to estimate yield, the weekdays are usually grouped in one stratum and weekends and holidays in another. This has been done because of the heavier daily fishing pressure and harvest on weekends. Many studies have demonstrated this fact (e.g. Churchill and Snow, 1964; Grosslein, 1961; and Stewart, 1964). These differences held true in this study also (Brown, 1969), for only in one case (Kingfisher Lake) did the effort on weekends approach the 28 percent of the total figure that the stratum would have had if the effort was distributed evenly (Table II). However, as Carlander et al. (1958) have pointed out, creel survey designs have been mainly based on the distribution of effort and althoughthis is proper for estimating effort, it may not be so for estimating other statistics. The weekday percentage of fish caught was greater than the percentage of effort (Table II).

The species composition of the catch did not differ significantly when the weekend-weekday catch compositions were compared using the Wilcoxin signed rank procedure (Wilcoxin and Wilcox, 1964). Although there were absolute differences between these two periods, there was no explainable pattern. However, the fact that these differences did exist would indicate that any catch composition based only on one period should be made with the realization that there might be a change if both periods were considered.

Characteristics of fishing parties are presented in Table III. On seven of the ten lakes, the average party size was larger on weekends. There was no difference on the other three. The overall difference was significant in a Wilcoxin signed rank test. The average number of hours fished by parties did not differ significantly. Catch rates in number and pounds were significantly lower on weekends as was the percentage of successful fishermen.

EVALUATION OF STRATA WITHIN WEEKDAY-WEEKEND PERIODS

In this survey; access areas, time of year (or cycle), days and time of day (a.m. or p.m.) were used as strata in selecting the sampling schedule. A cycle is the number of weeks required to sample each day in each access area (see Brown, 1969, for a more detailed description). An evaluation of the effectiveness of such strata for the following eight creel statistics: size, number caught, pounds caught, number caught per hour, and pounds caught per hour, hours fished, and man-hours fished was conducted by the use of analyses of variance computed separately for each lake for both weekdays and weekends. The basic analyses tested the following terms: area, cycle, day, time, day X cycle, and time X cycle. When terms did not apply in a particular case they were eliminated from the

Table I. Characteristics of Oklahoma Department of Wildlife Conservation Lakes

Lake	County	Acreage	Maximum depth in feet	Access areas
Beaver	Jefferson	42.9	28	2
Burtschi	Grady	180.0	28	3
Dahlgren	Cleveland	26.4	20	2
Hall	Harmon	36.2	28	1
Kingfisher	Kingfisher	58.0	20	3
Ozzie Cobb	Pushmataha	69.4	20	1
Roman Nose	Blaine	60.0	24	1
Schooler	Choctaw	28.5	24	2
Schultz	Texas	56.8	14	2
Vincent	Ellis	169.0	41	2

Table II. Percent Annual Distribution of Effort and Harvest by Periods

Lake	Period	Number of Parties%	Number of Fishermen%	Hours Fished%	Number Caught%	Pounds Caught%
Beaver	Weekday	64	67	69	68	57
	Weekend	36	33	31	32	43
Burtschi	Weekday	53	47	37	57	55
	Weekend	47	53	63	43	45
Dahlgren	Weekday	60	53	55	66	76
	Weekend	40	47	45	34	24
Hall	Weekday	57	57	52	62	49
	Weekend	43	43	48	38	51
Kingfisher	Weekday	71	71	71	71	72
	Weekend	29	29	29	29	28
Ozzie Cobb	Weekday	43	37	41	49	48
	Weekend	57	63	59	51	52
Roman Nose	Weekday	40	40	30	59	51
	Weekend	60	60	70	41	49
Schooler	Weekday	43	39	40	38	43
	Weekend	57	61	60	62	57
Schultz	Weekday	53	47	45	51	53
	Weekend	47	53	55	49	47
Vincent	Weekday	51	49	52	59	52
	Weekend	49	51	48	41	48

Table III. Weekday-Weekend Comparison of Annual Fishing Characteristics

Lake	Period	Percent Successful	Number per Hour	Pounds per Hour	Hours Fished	Party Size
Beaver	Weekday	47.7	2.90	.17	2.9	2.4
	Weekend	42.2	3.00	.20	2.6	2.4
Burtschi	Weekday	39.4	.60	.25	2.9	1.9
	Weekend	31.6	.30	.10	4.3	2.4
Dahlgren	Weekday	28.4	.18	.10	3.7	2.4
	Weekend	19.0	.11	.04	3.5	3.1
Hall	Weekday	67.3	.50	.04	3.2	2.1
	Weekend	62.8	.30	.04	4.0	2.1
Kingfisher	Weekday	31.9	.10	.10	2.7	1.7
	Weekend	14.8	.10	.10	2.7	1.7
Ozzie Cobb	Weekday	51.5	.64	.23	3.8	2.5
	Weekend	41.6	.46	.17	3.2	3.2
Roman Nose	Weekday	24.1	.30	.12	2.8	2.7
	Weekend	21.8	.10	.05	4.3	2.8
Schooler	Weekday	34.3	.60	.20	2.3	2.2
	Weekend	28.7	.60	.20	2.3	2.2
Schultz	Weekday	35.2	.30	.26	4.2	2.0
	Weekend	34.3	.24	.18	4.7	2.5
Vincent	Weekday	51.0	.36	.16	3.8	2.6
	Weekend	45.0	.21	.12	5.8	2.8

analysis. Cycles were not part of the design on Lakes Kingfisher, Schultz, and Vincent. On Lake Schooler on weekends a whole day sample was taken rather than two half days and thus no morning versus afternoon comparison was possible.

Area Comparisons: Differences between estimated values from fishermen sampled at the various access areas were tested for significance for Lakes Beaver, Burtschi, Hall and Schooler. These differences were not significant on Beaver on Schooler in any case. For Burtschi two of the eight possible comparisons were significant. These were the weekday values for parties and the weekend values for hours fished. For Lake Hall, the differences were significant for number of parties on weekdays and weekends, for hours fished on weekends, pounds harvested on both weekends and weekdays and pounds-per-hour on weekdays only. Apparently, only for Lake Hall was there a consistent difference between the fishing data collected at the different access areas.

Time of Year Comparisons: As might be expected, differences were usually significant. Number of parties, hours fished, and pounds caught were at maximum levels in the April, May, and June period. The midwinter period of December through March received the least fishing. The distribution of pounds caught per hour of fishing time was much more erratic than the other categories. However, there was still a definite peak in the April through June cycle.

Day Comparisons: The analyses of variance for the differences between the days of the week for weekdays and between Saturday and Sunday for weekends were not significant, as far as number of parties, hours fished, catch in pounds, and pounds-per-hour were concerned.

Morning and Afternoon Comparisons: In 17 of 19 possible comparisons (weekday and weekend strata on each of 9 lakes and the weekday strata on Lake Schooler) there was a significant difference between the number of parties completing fishing in the morning versus the afternoon. In only two cases did the greater number of fishermen complete their trips in the morning. On Lake Roman Nose on weekends the values were 3.2 and 3.1, and on Lake Hall the values were 1.4 and 1.0 for a.m. and p.m. respectively. The difference was significant in the latter but not in the former.

Differences in hours fished paralleled those of parties. In no case did the number of hours fished by anglers completing their trips in the morning exceed that of those who fished in the afternoon.

Fewer of the comparisons of pounds caught were significant (8 of 17) when contrasted with the previously mentioned statistics. However, in every case but one (Hall weekends) the afternoon surveys showed greater poundage than in the morning. Only for Dahlgren weekdays were the values (2.20 and 2.26) similar.

The catch in pounds-per-hour showed no trend in the morning-afternoon differences. Only six of the 19 comparisons had significant differences. Of these six, the catch-per-hour value was highest in the morning in only one case, but in the 13 non-significant comparisons, the morning values were higher in six while in one case the values were identical.

In several instances, the day x cycle interaction terms were significant in the analyses of variance. Whenever interaction occurs a closer scrutiny is required, in this case, to determine whether or not the differences from cycle to cycle invalidate the overall conclusions. When differences within cycles were examined, the significant interactions appeared due to a very small difference in favor of the morning in a cycle in which there was very little fishing, combined with large differences in favor of the afternoon in the other cycles when fishing pressure was heavy.

RELATIONSHIPS BETWEEN CREEL STATISTICS

The relationships of catch per unit effort to hours fished is particularly important in any creel survey design of the roving type in which a checker traverses the fishing area at appointed intervals interviewing fishermen in the act of fishing (Robson, 1961; Johnson and Wroblewski, 1962). The fishermen who fish the longest have a greater probability of being interviewed in this type of survey. Any measure that correlated highly with the number of hours fished will be estimated with a bias in the roving type designs which sample incompleted trips. The reverse bias could hold true in short segment sampling of completed fishermen trips in which parties fishing the shorter number of hours would be sampled more frequently. This was true in the morning samples taken in the present survey, where only those parties leaving before noon were interviewed while those who started early in the morning but fished a long enough period to carry them into the afternoon were missed. For these reasons the relationship between catch rate and hours fished was studied. For each comparison correlation coefficients were computed. First and second degree equations were calculated and analyses of variance used to determine whether or not the reductions in variation due to the linear and then the curvilinear term were significant. In none of the comparisons were the curvilinear terms significant. Since in certain surveys it may be valuable to utilize statistics from successful fishermen only, to obtain a measure of fishing success that might be more sensitive to actual changes in the fish population, all of the above procedures were applied to that group as well as to the total. Analyses were performed for each lake's data separately for both weekdays and weekends. The correlations coefficients are presented in Table IV.

Table IV. Correlation Coefficients Between Creel Statistics in the Oklahoma State Lake Creel Survey

Lake Period	Catch rate in nos. vs. hours fished: All fishermen	Catch rate in nos. vs. hours fished: Successful Fishermen only	Catch rate in lbs. vs. hours fished: All fishermen	Catch rate in lbs. vs. hours fished: Successful fishermen only	Catch rate in nos. vs. party size: All fishermen	Catch rate in nos. vs. party size: Successfull Fishermen only
Beaver						
Weekday	0.06	-0.15	-0.08	-0.19	-0.02	-0.13
Weekend	0.13	-0.16	0.06	-0.12	0.01	-0.20
Burtschi						
Weekday	-0.01	-0.18*	0.01	-0.15	-0.06	-0.10
Weekend	-0.02	-0.20*	-0.02	-0.13*	-0.13*	-0.23
Dahlgren						
Weekday	0.10	-0.24	0.10	-0.21	-0.14	-0.21
Weekend	-0.03	-0.21	0.05	-0.24	-0.10*	-0.26*
Hall						
Weekday	-0.18	-0.33	-0.13	-0.41*	-0.01	-0.04
Weekend	-0.12	-0.30	-0.13	-0.47*	-0.14	-0.20
Kingfisher						
Weekday	0.26*	-0.34	0.00	-0.57*	-0.07	-0.40
Weekend	0.20*	-0.18	0.23*	0.31	-0.08	-0.16
Ozzie Cobb						
Weekday	-0.07	-0.28*	0.01	-0.20	-0.12	-0.21
Weekend	0.03	-0.18	0.01	-0.22*	-0.10	-0.27*
Roman Nose						
Weekday	-0.11	-0.30	-0.04	-0.45	-0.11	-0.24
Weekend	-0.08	-0.30*	-0.04	-0.09	-0.12	-0.12
Schooler						
Weekday	-0.16*	-0.37	-0.16	-0.37	-0.14	-0.39
Weekend	-0.13	-0.34	-0.11	-0.32	-0.14	-0.36
Schultz						
Weekday	0.08	-0.29	0.05	-0.34	-0.30*	-0.29
Weekend	0.25*	0.09	0.23	0.06	-0.29*	-0.30*
Vincent						
Weekday	-0.04	-0.13	-0.14	-0.13	-0.07	-0.17
Weekend	-0.05	-0.19	0.00	-0.12	-0.08	-0.19*

Table IV. (continued)

Lake Period	Party Size vs. Hours Fished: All Fishermen	Party Size vs. Hours Fished: Successful Fishermen Only	No. of Observations: All Fishermen	No. of Observations: Successful Fishermen Only
Beaver				
Weekday	0.17	-0.24	102	47
Weekend	0.03	-0.14	129	53
Burtschi				
Weekday	-0.10*	-0.13	486	193
Weekend	0.06*	0.03	1025	292
Dahlgren				
Weekday	0.12	-0.04	201	56
Weekend	0.08	0.11	336	63
Hall				
Weekday	-0.03	-0.11	48	33
Weekend	0.01	0.03	126	78
Kingfisher				
Weekday	0.05	0.72*	75	13
Weekend	-0.12	-0.30	100	14
Ozzie Cobb				
Weekday	0.07	-0.21	167	85
Weekend	0.06	-0.04	278	119
Roman Nose				
Weekday	-0.23*	-0.21	143	35
Weekend	-0.01	0.17	219	48
Schooler				
Weekday	0.48*	0.69*	35	12
Weekend	0.67	0.75*	51	14
Schultz				
Weekday	0.05	-0.25	90	32
Weekend	0.15*	0.01	204	70
Vincent				
Weekday	-0.04	-0.09	217	110
Weekend	0.02	0.04	504	226

*Significant at 0.05 level

Catch Rate Versus Hours Fished: A correlation coefficient was calculated separately for weekends and weekdays between both catch-per-hour in pounds and in numbers and hours fished for parties. When all fishermen were considered only three cases (Kingfisher and Schultz weekends) had correlation coefficients that were significant, and for one of these cases, the correlation coefficient was not significant for pounds-per-hour (Table IV). In the latter case, most of the catch consisted of channel catfish in which, for some unknown reason, the larger size fish comprised the smaller numerical catches. The r^2 values in every case indicated that only very small proportions of the variation was accounted for by the covariable. The highest r^2 value was 0.07.

The successful, and thus probably the better fisherman in every case showed a negative correlation. On the forty possible correlation coefficients, eleven were significant. The highest r^2 value was 0.33.

Since catch rate of all fishermen combined was not related to the number of hours fished, no bias would result in an estimate of catch-per-unit effort based on a sample of fishermen that fished a different length of time than the overall average. However, if this index was based solely on the results of successful fishermen, a small negative bias would result from oversampling the longer trips and the reverse would occur if they were under-sampled.

Catch Rate Versus Party Size: Correlation coefficients were calculated for catch rate in numbers-per-hour and party size both for the respective situations when all the parties and when only successful parties were considered. In every case, the correlation coefficient was negative. Even though very few of these were significant, the fact that all were negative gives credence to the conclusion that larger size parties did have the tendency to catch fewer fish. Watt (1959) found a negative correlation between catch rate and party size in a smallmouth bass fishery in Lake Huron. He considered this due to gear competition, but it could also have been a result of poorer anglers fishing in larger parties. Correlation coefficients were significant only for four cases when all trips were considered and for five cases when successful trips only were considered (Table IV). The largest significant r^2 value was only 0.09, which indicated that the relationship was of little effect.

When the correlation coefficients were compared for each category for the total fishermen versus the successful only fishermen, there was a definite increase in correlation evident (Table IV). Of twenty possible comparisons, there were only three cases where the absolute value of the correlation coefficient was smaller when the total number of fishermen were used, and in those cases the differences were very slight while many of the negative differences were quite large. A Wilcoxin signed rank test was applied to these data and the difference was significant. This indicated that in most cases zero catches were distributed among parties of all sizes, but that with the removal of these cases there was more evidence for a slight decrease in catch rate with increasing party size.

Party Size Versus Hours Fished: The correlation coefficients between party size and hours fished when all fishermen were considered were significant for only six cases. The correlations were negative for three of these. In those latter cases, the reduction in variation, due to the covariate, were very slight as the r^2 values were only 0.05, 0.02, and 0.01. Only per two of the positive correlations were the reductions in variation of any magnitude with r^2 values of 0.25 and 0.44.

When just successful parties were considered, three relationships were significant. In all three cases the relationship was positive and of a reasonable amount of magnitude — the r^2 values being 0.48, 0.56, and 0.52. Since the catch rate decreased with increasing party size, the estimate of catch-rate would be biased where party size was related to number of hours fished and the sample was not representative in this regard.

EVALUATION OF MISSING DATA

This survey was intended to be a complete census of all fishermen leaving the lake at a particular access area during the time that the survey taker was on duty. As would be expected, such perfection was not achieved. There were cases where individual parties were not interviewed during the sampling period. Also, some interview forms had to be rejected because the data appearing on them was judged to be invalid by the regional biologists or the author. These problems are discussed in this section.

Missing interviews fell into two categories. The first were those of fishermen that left when the checker was temporarily not at his duty post. Because of the small size of the lakes, the checker was able to determine the number of parties that had left during his absence. The assumption was made in this study that creel statistics of such individuals did not on the average differ from those of interviewed fishermen. This was probably valid. The second were those of fishermen who refused to stop for the checker. The only statistic obtained for these two groups of fishermen was party size. Very few parties were missed except on Lakes Burtschi and Roman Nose.

In these two cases, the average party size for interviewed and uninterviewed fishermen respectively was 3.6 and 3.7 for Lake Burtschi and 2.8 and 2.9 for Lake Roman Nose. Because of the closeness of these values, at least some confidence can be given to the assumption that noninterviewed fishermen were similar to the interviewed fishermen.

Creel checkers were instructed in the details of interviewing fishermen and completing the survey form. However, there were often errors on the code sheets that resulted in certain interviews being of limited usefulness.

When one or more of the following categories, party size, hours fished, and the number and pounds of fish caught, were either omitted from the forms, or were obviously inaccurate; the interviews were classifed as unusable and used only in the estimates of party numbers. Six lakes had such missing interviews (Table V). The estimates of other statistics such as pounds harvested were obtained by multiplying the average pounds caught by interviewed parties times the estimated total number of parties. This assumed that values of the missing interviews were similar to the values used.

To test this assumption, all of the rejected interview forms were scrutinized and classified for each lake according to the reason for their classification as unusable. Forms were rejected because of missing data in the following categories: parties, hours, numbers, and pounds caught. Some were unusable for other reasons, i.e., number of hours or the size of fish were far too large, etc. For rejected interviews which still contained usable information on one or more of these categories: average party size, number of hours fished, number of fish caught, and pounds of fish caught, were calculated. That is, an interview was used in computing the average party size if that value was usable, even though other items such as number of hours were not. These average values were then compared (using t-tests) to the corresponding annual values estimated from the survey for the respective lake given in Table V.

Average party size reported on rejected forms was very close to the overall estimate in all but Lakes Burtschi and Ozzie Cobb. The unusuable forms gave an underestimate in the first case and an over-estimate in the second. The former difference was not significant but the latter was. Only on these two lakes would the overall estimated number of fishermen probably have been changed if the rejected interviews had been usable. Hours fished by parties whose interview forms were rejected differed significantly from the overall estimate only for Lakes Burtschi and Ozzie Cobb. In five of the comparisons, the absolute difference was that of more hours fished being recorded on the unusable forms.

Table V. Comparison of Averages of Creel Statistics for Rejected Interviews With Estimated Annual Values

Lake	Rejected Forms	Annual Estimate	Significant	Rejected Forms	Annual Estimate	Significant
		Party Size			Hours of Effort	
Beaver	2.5	2.4	No	3.1	2.8	No
Burtschi	2.2	3.6	Yes	5.1	2.2	Yes
Hall	2.4	2.1	No	4.1	3.6	No
Ozzie Cobb	3.4	2.9	No	7.6	3.4	Yes
Roman Nose	2.6	2.8	No	3.1	3.7	No
Vincent	2.8	2.7	No	6.7	5.4	No
		Number of Fish Caught			Pounds of Fish Caught	
Beaver	0.9	1.9	Yes	0.14	0.12	Yes
Burtschi	5.0	3.0	No	0.51	1.34	Yes
Hall	0.2	3.1	Yes	0.17	0.30	No
Ozzie Cobb	10.7	5.3	No	0.40	1.92	Yes
Roman	3.7	1.6	No	1.71	0.72	No
Vincent	9.2	4.1	Yes	2.33	2.02	No

On Lakes Beaver and Hall the fishermen whose interview forms were rejected caught significantly fewer fish than fishermen in the overall estimate. The only other significant difference was in Lake Vincent where the value for the number of fish caught reported on the unusable forms was higher than the overall estimate for the lake.

The rejected interview forms reported lower catch in weight than corresponding estimates in all cases but Lake Vincent. These differences were significant on Lakes Beaver, Burtschi, and Ozzie Cobb. As these differences did exist, especially in the hours fished, the necessity of keeping the number of such unusable forms to a minimum should be stressed.

IMPLICATIONS FOR CREEL SURVEY DESIGN

In many studies reported in the literature sampling intensity was allocated in proportion to fishing effort (e.g. Cole and Finkelstein (1959), Gasaway (1967), Lambou and Stern (1959), and Robson (1960)). Taylor and Carroll (1967) on Norris Reservoir, Tennessee, used probability related to effort to select times for making airplane flights to make fishermen counts and they included Wednesday in the weekend strata because local businesses closed that afternoon. Elser (1960) determined that the time period 11:00 a.m. to 2:00 p.m. had the least variation and the peak fishing pressure in the Northeast River in Maryland so he made his counts at that time. Green (1968) in Dryden Lake, New York, weighted morning and afternoon strata by the proportion of effort expended in the previous year.

Abramson and Tolladay (1959) reported a survey where sampling was based on the optimum allocation technique outlined by Cochran (1963). In this method samples are allotted to the various strata proportional to the variance and the size of that stratum (ignoring cost). Using previous year's data for fishing pressure at Moss Landing Pier in Monterey County, California, they determined the number of days necessary to sample in order to obtain a 95 percent confidence interval with a one-half width of 15 percent of the total effort for a simple random sample, a sample allocated proportional to the effort, and the optimum allocation. Sundays and holidays were one stratum, Mondays and Fridays following holidays plus Saturdays were another, and the remaining weekdays the third. The equivalent sample sizes were 100.9, 54.0 and 39.1 days respectively and thus the optimum allocation was definitely superior. Tait (1953) in his studies of Michigan lakes also found that optimum allocation based on effort was the most efficient. Obviously, if a survey is primarily designed to estimate effort then a sampling intensity should be related to the distribution of effort. If, however, other items form the objectives of the survey, then a design based on the distribution of effort will be satisfactory only insofar as those items are correlated with effort.

In the present study, the average of the weekday-weekend percentage distribution of effort was 53.5 on weekdays and 46.5 on weekends for parties, 50.7 to 49.3 for fishermen, and 49.2 to 50.8 for hours. There were, however, lake-to-lake variations. The overall ratios support the decision in this survey to sample the two strata equally. The expected heavier daily fishing pressure on weekend days was the basis for the decision to sample each weekend day at a higher rate than each weekday day.

Although this relatively equal distribution of sampling effort was reasonable in this study, based on the effort expended, other studies have shown that such equal proportioning of fishing effort does not always occur. In a resort area lake in Wisconsin, Churchill and Snow (1964) found that only 32 percent of the fishing was done on weekends in the summer while the winter weekends accounted for 64 percent of the fishing effort. Boland (1960) in Parvin Lake, Colorado, found that approximately two-thirds rather than half of the effort and catch occurred on the weekends. Obviously, the distribution of fishing effort for the

particular lake in question should be evaluated before apportioning sampling effort to weekday strata and, in fact, before even deciding to use weekdays and weekends as strata.

Within the weekday and weekend strata the question arises as to whether any further stratification is necessary. The analyses of variance computed for the data collected in this survey demonstrates clearly that there would be no advantage in further consideration of the days of the week within these strata. The greater amount of effort of fishermen who finished their trips in the afternoon periods indicated that an equal weighting of a.m. and p.m. strata was not the most efficient sampling scheme. The overall percentage distribution of afternoon to morning hours fished was 71.2 to 28.8. The distribution of sampling effort should probably follow this ratio. The heavier afternoon use agrees with Green's (1968) finding in a warm water lake in New York State and Tait's (1953) work in Michigan but not with Mraz (1964) who found equal effort in a Wisconsin lake. Green (1968) altered his sampling effort for morning and afternoon periods based on the distribution of fishing effort.

Carlander *et al.* (1958) pointed out that little attention has been given to criteria other than fishing effort in designing creel surveys. A review of current literature demonstrates that this conclusion is still valid. If the main object is to estimate the total catch then the sampling scheme should be designed to optimize that value by sampling the periods with the greatest variation in the catch with the highest sampling ratio. The proportioning of the catch into weekday and weekend periods varied from lake to lake. The mean of the proportions for the various lakes was 58.0 for weekdays and 42.0 for weekends for numbers and 55.6 and 44.4 for pounds. The analyses of variance of the data from these Oklahoma lakes indicated that no further consideration of the exact day within each period needs to be made if catch is the primary statistic desired.

The heavier catch recorded in the afternoon as compared to the morning points to the inefficiency of choosing one morning and one afternoon half day to sample for each weekday and weekend period as was done in the present survey. The overall percentage of the pounds reported in the afternoon was 67.9 and in the mornings 32.1. Mraz (1964) found numbers caught to be equally distributed between a.m. and p.m. periods but for the greater weight to be caught in the afternoon and evening in Brown's Lake, Wisconsin. There was a significant correlation in this study found between catch and hours fished, which means that a sampling scheme which overweighted the morning period would sample those fishermen who fished for shorter periods with greater frequency and thus underestimate the catch.

In sport fisheries, the primary goal is fisherman satisfaction with effective use of the resource. Therefore some measure of the fishing quality is desired. The most common measure of quality is the catch (in terms of both numbers and pounds) per man-hour (Lambou, 1966). This has been the value used in this study although the simpler expression catch-per-hour has been used. I concur with Lambou's (1966) recommendation that this is a preferred statistic to the only other commonly used measure, catch-per-trip, which does not take into account the variation between trip lengths.

There have been two types of average catch-per-unit effort calculations. The first is obtained by dividing the total estimated catch by the total effort, and the second is the average of the individual catch-per-unit effort calculated for each fisherman or party. The former was the method used in this study. Grosslein (1961) has pointed out that the latter would not be equivalent to the former in a survey where probability of contact with a fisherman was correlated with that fisherman's trip length, and if there was a relationship between time fished and catch-per-hour. He found no such correlation in data from Oneida Lake, New York. Di Costanzo (1956) also found no such correlation in his study on Clear Lake, Iowa. In the present study few significant relationships were found between numbers-per-hour or pounds-per-hour both for all fishermen and for successful fishermen only with trip length, although there was some indication

of a slight negative relationship for successful fishermen. These findings indicated that either measure could be used successfully on these lakes.

It is tempting to design creel surveys aimed at obtaining a catch-per-unit effort index on the basis of fishing pressure by concentrating sampling on those periods with the greatest effort more heavily than the distribution of effort would warrant. Thus, the greatest number of fishermen would be contacted with the least expenditure of effort. There are two ways this could be accomplished. The first is by concentrating on contacting those parties that had the largest number of fishermen and the second is to concentrate survey effort on those periods (such as weekends) when the fishing pressure was heaviest. These are reasonable procedures only if fishing success is not correlated with party size or fishermen numbers. For both the total and successful fishermen, only categories investigated in this study, a small decrease in number caught-per-hour with increasing party size was indicated. On weekends when the number of fishermen was greater, the average party size was larger, the percentage of successful fishermen less, and the catch-per-hour lower than on weekdays. Samples designed to estimate catch-per-unit effort would have given an underestimate if they had been directed mainly toward sampling larger size parties on weekends. This contrasts with Grosslein's (1961) conclusion of no weekday-weekend differences of practical significance and with Hansen (1966) who found no close relationships between effort and success on Glendale Lake, Illinois. Within weekday and weekend strata there was no evidence for daily differences in catch-per-unit effort. Morning and afternoon comparisons of pounds caught-per-hour indicated no overall significant differences. Therefore, it would seem reasonable to concentrate efforts in the afternoon periods when the effort and catch were greatest. Given the same variation in both periods, the standard error and catch were greatest. Given the same variation in both periods, the standard error of the estimated values would be smaller for the afternoon data as the number of interviews would be larger. Grosslein (1961) also found no significant changes in catch rate in Oneida Lake, New York, in the period from daylight to dark.

On the basis of this study, surveys designed to estimate the catch-per-unit effort should be stratified on the basis of weekday-weekend effort and be designed to include all fishing on an unbiased basis. Within these strata, however, it would seem valid to concentrate sampling effort at the peak times that the fishermen complete their trips. These times could be sampled proportionately if a total were to be estimated and overproportionately if only an index of fishing success was desired.

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