A COMPARISON OF TELEPHONE, MAIL AND CREEL SURVEY RESULTS FOR ANGLER SUCCESS AND TIME SPENT FISHING IN SIX NEW MEXICO LAKES

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DISCLAIMER

ABSTRACT

Statewide telephone estimates of angler success and fishing effort from April 1988 through March 1991 were compared with the results of a statewide mail survey and a creel (field) survey at six lakes in northern New Mexico. About 1,350 telephone interviews were completed annually using monthly random calls to all New Mexico households. Survey forms were mailed annually following each license year to a 10-percent random sample of licensed anglers. Over 4,000 survey forms per year (about 22%) were returned. A two-part access point creel survey was conducted at parking lots, where angler success and effort were measured upon return from fishing, and at road exits from the sites, where number of fishing trips per year were estimated. Telephone and mail survey estimates of sportfish harvest/hour (HPUE) did not significantly differ and estimates of both statewide methods similarly exceeded creel survey estimates. The mean estimates of total annual harvest resulting from the telephone surveys were greater than the mail and creel survey estimates. Despite overestimated HPUE by the mail survey, mail survey estimates of mean annual harvest were similar to the creel survey estimates because total annual effort was underestimated by the mail survey. Telephone estimates of HPUE and the angler hours fished per trip exceeded the creel survey estimates. Errors may have occurred because of poor recall and telephoned angler confusion of party harvest with individual harvest.
Keywords: Anglers, harvest, fishing effort, surveys

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INTRODUCTION

Accurate estimates of annual angler effort (sport-fishing time), catch and harvest are needed to measure angler success (Robson 1961, Erman 1972, Low et al. 1985) and relative sport fish abundance (Farman et al. 1982, Crone and Malvestuto 1991) using catch per unit effort (CPUE) and harvest per unit effort (HPUE) indices. These data often are used to monitor how angler effort and fish harvest respond to both natural and management-induced changes in fisheries. These data also are needed to characterize site quality for estimating angler economic benefits (Cole et al. 1992a) and other measures of angler satisfaction (Cole et al. 1992b).

Numerous methods have been used to estimate CPUE, HPUE and annual angler effort and harvest (Guthrie et al. 1991). Among the methods are: 1) field surveys (creel surveys) in which anglers are interviewed on site during or after their fishing experience (roving or access-point surveys); 2) mail surveys in which anglers are usually asked to recall several months to a year of fishing activity and successes; and 3) telephone surveys that address issues similar to mail surveys and are administered at various intervals. Of the three survey types, creel and mail surveys have had the longest history of use in New Mexico and elsewhere (Guthrie et al. 1991). This report's primary purpose is to compare the telephone survey results with simultaneously conducted mail survey and creel survey results completed at six New Mexico reservoirs from April 1988 through March 1991.

The three types of surveys have advantages and disadvantages (Brown 1991, Hayne 1991, Weithman 1991). Two important considerations are sample representativeness and sampling cost. Inexpensive but inaccurate or imprecise data may misguide management decisions. Usually creel surveys are most costly while mail surveys typically are least costly. But cost differences between mail and telephone surveys begin to diminish with the degree of follow-up required to obtain acceptable return rates for mail surveys. Costs associated with creel surveys are high for each observation because of the time and travel required for data gathering. Yet creel surveys offer the advantage of trained personnel directly observing the fish harvest. When done correctly, this can reduce errors introduced in survey interviews. Low-response bias is virtually eliminated. Creel survey response rates may approach 100 percent although care must be taken to separate anglers from non-anglers. When carefully designed and executed, creel surveys generally are assumed to be more accurate than either mail or telephone surveys.

Creel surveys have disadvantages, however. Their higher cost usually makes them economically impractical for estimating regional or statewide HPUE and annual harvest, information of great importance to managers. Depending on location, fishing behavior, and costs, biased creel surveys may be unavoidable at many sites. The greatest analytical problems associated with roving creel surveys deal with representative sampling. Accurate estimates of angler effort at large sites often require overhead flights or other whole-site sampling to estimate total effort without bias. Problems remain, however, in discriminating anglers from non-anglers and detecting all anglers (Hayne 1991). Small sites are more readily sampled with roving creel surveys than are large sites. Sampling accuracy may be improved by interviewing anglers at access points as they leave a site. Angler responses for completed outings may be less biased in estimating CPUE and HPUE than are responses for incomplete fishing trips (Robson 1961, Malvestuto et al. 1978, MacKenzie 1991). Anglers are more easily distinguished from non-anglers in access-point surveys (Hayne 1991). But where sites have several access points and large differences in angler use at each access point, the annual effort and harvest variation can exceed that of roving creel surveys (Hayne 1991). The use of a "bus route" design (Jones and Robson 1991) may improve access-point precision for estimating annual angler effort at sites where great variation exists among numerous exit points. Annual effort will be underestimated if anglers in any way avoid monitoring at access points or if all access points are not identified and sampled.

Telephone and mail surveys allow anglers to be remotely and less expensively sampled at some time following their fishing experience. These are choice methods for sampling large geographic areas. The potential for miscommunication and inaccuracies associated with angler recall is a problem, especially when long lapses occur between experience and activity

(Chu et al. 1989, Thompson and Hubert 1990, Weithman 1991, Tarrant et al. 1993). Another problem is angler knowledge whenever data pertaining to fish species or size is requested (Brown 1991, Weithman 1991). Telephone and mail response rates typically are lower than for creel surveys. Bias may be introduced when the fraction of non-respondents is significant, depending on how much difference exists in the experience of respondents and non-respondents (Brown and Wilkins 1978, Tarrant et al. 1993).

Telephone surveys usually have a greater response rate than mail surveys, even when expensive follow-up efforts are made for mail surveys (Brown and Wilkins 1978, Brown 1984). Response bias is related to the motives associated with returning mail surveys or participating in a telephone interview. Avid anglers are more likely than less avid anglers to respond to mail surveys (Brown and Wilkins 1978, Tarrant et al. 1993). Even 70 percent mail returns showed evidence of non-respondent bias (Brown and Wilkins 1978). Therefore, mail surveys are expected to provide high estimates of success, total harvest, and total effort compared to creel surveys, as long as no other factors affect the estimate. Telephone surveys also have potential interview biases that must be managed. There can be strong demographic biases associated with telephone ownership and who answers the telephone. Not everyone contacted agrees to an interview and little is known about non-response bias in telephone surveys.

Telephone surveys are more practical than other methods for sampling frequently (e.g., monthly) over large geographical areas while simultaneously sustaining a reasonably high response rate. Telephone surveys provide greater flexibility than mail surveys. The branching techniques often used in telephone interviews are less practical in mail surveys (Brown 1991) and experienced telephone interviewers can probe when answers are vague or inappropriate.

Memory lapse, fabrication and question misinterpretation are important potential error sources when there is no opportunity to verify the respondent's estimates of number and sizes of fish caught and fishing location (Chu et al. 1989, Weithman 1991). Memory-related errors occur when anglers cannot exactly recall their fishing experiences. Chu et al. (1989) found that effort and harvest estimates tended to increase with increasing time lapses between the activity and the interview. Depending on how interviews are telephone interviews are conducted, biases may be introduced as the interviewer interacts with the surveyed individual (Brown 1991). Poorly framed questions may cause misinterpretations by anglers or surveyors.

The choice of sampling licensed anglers versus sampling the entire population could impact accuracy. Limiting the sampling universe to licensed anglers may bias the results toward more avid anglers. Sampling all households by telephone is more costly than sampling only licensed angler populations. But it may be less biased because respondents include unlicensed anglers and anglers who buy licenses less often than every year.

Sampling all households by telephone is more cost effective than sampling all households by mail survey.

The New Mexico Department of Game and Fish (NMGF) recognized the need for statewide surveys of angler success and harvest before 1975 (Patterson 1977), when a mail survey was initiated. The mail survey was conducted for license years 1975, 1978, 1981-1986 and 1988-1990. Questions about the mail survey accuracy emerged primarily because of low angler response (about 20-25 percent) and obvious misidentification of species and sites. The access-point creel survey was designed to test the mail survey's accuracy of the mail survey. Comparison of mail and creel survey results with telephone survey results became an objective with the initiation of this project.

The telephone survey was initiated in 1988. Its primary purpose was to gather data for model development of a model of angler-use rates and angler economic benefit incorporated in RIOFISH (Cole et al. 1990, 1992a), based on fishing success and other site-related factors. Because data similar to the creel and mail survey were collected in the telephone survey, the opportunity arose to evaluate the differences in creel, mail and telephone survey estimates of angler success and effort.

METHODS

Creel Survey

The creel survey was conducted at Heron, Eagle Nest, Bluewater and Fenton lakes in license years 1988-89. Because of problems with traffic counters and road interviews, only estimates of HPUE, CPUE and RPUE (return per unit effort) were compared for Heron and Bluewater lakes. In the remaining two license years of study (1989-90 and 1990-91), the creel survey was conducted at Eagle Nest, Fenton, Charette and Clayton lakes. The creel survey had the most complex design among the three surveys. It incorporated two separate interviews; one focused on estimating trip departures on roads exiting the site (road interviews) and another focused on estimating CPUE and HPUE at the site's parking areas at the site, usually near boat ramps (ramp interviews). The design included using traffic counters at the main-road departure points as described by Bosland (1991) and Urquhart et al. (1993).

Departures from the site were measured in the road interviews where the traffic counters were located, only following completion of the entire trip. The number of anglers and the number of axles per vehicle were estimated in the road interviews. Vehicles leaving the site only temporarily were not included. Road interviews were conducted at locations where all exiting traffic could be stopped. Morning and afternoon road interviews of departing anglers were conducted within 6-hour periods to cover most of the daylight hours (8:00 to 14:00 for morning and 14:00 to 22:00 for afternoon). Departures outside this time frame were considered insignificant and therefore not sampled. The design was a latin rectangle composed of morning/afternoon, weekday/weekend, month, and exit (Urquhart et al. 1993). Creel clerks attempted to stop all vehicles except obvious utility vehicles. The number of vehicles not interviewed was recorded when traffic exceeded capacity to interview all vehicles. It was assumed that the ratio of anglers to total traffic (as measured by traffic counters) was the same as the ratio of anglers to interviewed traffic. The total number of angler trips was estimated by creating a linear model that predicted total trips during any time period (morning, afternoon, weekday, weekend, month) in the year, then summing across all time periods.

The parking area interviews were conducted with anglers who had finished their fishing for that particular outing on the lake, but not necessarily their whole trip to the site, which may have lasted several days for some anglers (throughout the text, outing is differentiated from trip according to the meaning indicated here). The design was stratified by morning and afternoon, weekday and weekend, and season. Again 6-hour intervals were sampled (8:00 to 14:00 for morning and 14:00 to 22:00 for afternoon). In the original design, all anglers were to be interviewed to determine individual success, but a large number of boat anglers pooled their harvest. Anglers, therefore, were asked to show all fish caught by the party when they had not kept fish separate. Observed fish were counted and measured by species. In some instances anglers did not show fish because of professed inaccessibility and the number was recalled from memory. Anglers recalled the number of anglers in the party and hours fished in that particular outing (time they started and time they stopped fishing). Anglers also were asked to recall the number of fish returned by the party; harvest and return were added to estimate the total catch for the outing. Party harvest and catch for each outing were divided by party hours (number of hours fished times the number in the party) of effort to estimate CPUE and HPUE. Total hours of effort were multiplied by CPUE, HPUE and RPUE to obtain total annual catch, harvest and return.

The sample sizes for creel, telephone and mail surveys are shown in Table 1. Among the three study survey types, the creel survey had the largest sample size. Although both residents and non-residents were included in the creel survey, only resident anglers were analyzed for this comparison study.

Telephone Survey

The telephone survey data reported here were collected from April 1988 through March 1992 in order to estimate monthly fishing activity from April 1988 through March 1991. The telephone survey was restricted to New Mexico residents in order to estimate benefits to New Mexico anglers. A simple random sample of state households with telephones was conducted from May

Table 1. The number of samples for telephone, creel and mail survey results in license years 1988-1991.

	1988-89	1989-90	1990-91
Bluewater			
Creel			
Harvest Rate	719	-----	-----
Total Harvest	38	-----	-----
Telephone	84	58	56
Mail	438	369	202
Heron			
Creel			
Harvest Rate	752	-----	-----
Total Harvest	31	-----	-----
Telephone	39	35	47
Mail	294	316	245
L.Charette			
Creel			
Harvest Rate	-----	305	316
Total Harvest	-----	31	31
Telephone	4	7	7
Mail	40	38	45
Clayton			
Creel			
Harvest Rate	-----	196	239
Total Harvest	-----	31	41
Telephone	6	4	5
Mail	12	13	11
Eagle Nest			
Creel			
Harvest Rate	1237	764	881
Total Harvest	48	43	55
Telephone	28	27	61
Mail	209	222	224

Table 1. (cont'd.)

	1988-89	1989-90	1990-91
Fenton			
Creel			
Harvest Rate	628	356	340
Total Harvest	36	43	45
Telephone	23	25	41
Mail	197	228	190

1989 through March 1992. Before May 1989, sampling was stratified according to the number of people in each county. Calls were made monthly, prorated so as to sample during summer months twice as frequently (150 samples/month from April through September) as warmer months (75 samples/month from October through March).

About 1,350 resident anglers were interviewed each year, but a small percentage of interviews were not used because of incomplete information. Sample sizes, shown in Table 1, were smallest for the telephone surveys. Calls were made by a professional polling firm in early evening hours when people were most likely to be home. A decision was made in the initial design to sample anglers age 14 and older partly because previous experience indicated that younger children were not easily or reliably interviewed. The study's main emphasis, economic benefits estimation, pertained to anglers in control of their travel costs and fishing destination, neither of which is routine for children under age 14. To correct for biases introduced by non-random answering of the phone in the household (adult males and teenagers are less likely to answer than adult women), a system was designed to determine first if any anglers lived in the house. Then the household angler at home, over age 13, and with the most recent birthday was asked to come to the phone for the survey.

The interviews included questions pertaining to this study and other questions pertaining to angler demographics, recreational satisfaction and expenditures. Interviews were typically 20-25 minutes long. With respect to this study, anglers were asked to recall their fishing success on the last trip (catch by species returned, harvest by species, sizes of harvested fish). They also were asked concerning their last fishing trip, the number of hours fished, where they fished, and how long ago they fished to the nearest week if less than two months ago or to the nearest month if more than two months ago. Each person was asked to recall the number of trips taken during the last 12 months.

The total number of fishing trips statewide was estimated from the product of average trip rate per angler, number of anglers over age 13 per household, and total household number in New Mexico. The statewide estimate of angler number (over age 13) per household (0.35) was determined by the initial screener survey. The number of anglers in each household contacted was continuously tallied during the survey. The number of state households was obtained from U. S. Census Bureau data. Eighteen percent of all households had one or more anglers over age 13. Because anglers under 14 were not included, the estimate of total annual effort, harvest and catch was expected to be conservative compared to the creel survey results, in which anglers of all ages were included.

Total angler effort/site/year and total harvest/site/year were estimated based on the fractions of last trips reported for each site out of the total number of last trips identified in interviews. Therefore, if 140 last trips were taken to a site out of a total of 1,400 last trips identified for the entire state, 10 percent of the estimated annual statewide trips was estimated for the site. Total annual effort was calculated from mean trip length in hours (asked in the interview for the last trip) and number of trips/year. Total annual harvest was calculated from HPUE and the total annual effort. Total annual catch and return were calculated similarly.

For the telephone survey, the total number of fishing trips to a site, V, was estimated by $V=(A)*(T)*(P)$, where A is the number of anglers who fished in New Mexico, T is the average number of trips per angler taken during the previous 12 months, and P is the fraction of trips taken to each site.
While A is a constant, T and P are random variables. Because the product of two variables was used to estimate total trips, the variance for total trips was estimated according to Goodman (1960):

$$\mathrm{Var}(XY) = X^2\mathrm{Var}(Y) + Y^2\mathrm{Var}(X) - \mathrm{Var}(X)\mathrm{Var}(Y).$$

Standard errors are the square roots of these variances of estimates.

Total annual harvest, catch and return were estimated as the product of total trips and the per trip harvest, catch or return, respectively. Standard errors were calculated with Goodman's (1960) formula.

Average harvest, catch and return rates and their standard errors for the telephone survey were calculated via the MEANS procedure of the Statistical Analysis System (SAS Institute Inc. 1990). This procedure yields the simple arithmetic mean of the sample and its standard error defined as the standard deviation of the sample divided by the square root of the sample size.

The telephone survey indicated that 13.4 percent of all sport fishing in New Mexico from 1988 through 1991 occurred at the creel sample sites (Table 2). Clayton and Charette lakes were much less visited than Heron, Bluewater, Eagle Nest, and Fenton lakes. Because Clayton and Charette lakes replaced Heron and Bluewater lakes in the last two years of the creel study, the percentage of New Mexico fishing trips sampled also decreased in the last two study years. Table 2 shows that the most exceptional season was autumn, when kokanee salmon (Oncorhynchus nerka) fishing was popular at Heron and Eagle Nest reservoirs.

Mail Survey

The New Mexico Department of Game and Fish has conducted a postal survey since 1975. Methods used are described in detail by Patterson (1977) and Urquhart et al. (1993). The survey was sent to a 10-percent random sample of all in-state and out-of-state license holders (excluding 1-5 day license holders) who were asked to list their harvest (kept fish) by species at all sites fished and all days of fishing over the past year. Anglers were sent the survey after March 30, the end of the license year. Only resident anglers were included in this comparison because the telephone survey was limited to state residents. Mail survey

Table 2. Percentages of resident angler visits each season and annually estimated from telephone surveys for the northern New Mexico study lakes and all sites in New Mexico for license years 1988 through 1991.

Sites	Winter	Spring	Summer	Fall	Annual	N
Bluewater	4.25	4.52	3.60	3.93	4.01	248
Heron	0.81	2.19	3.13	7.60	3.15	195
Charette	0.40	0.56	0.64	0.14	0.53	33
Clayton	0.40	0.37	0.32	0.27	0.34	21
Eagle Nest	5.26	2.80	2.49	5.29	3.15	195
Fenton	1.01	2.89	1.99	1.49	2.17	134
All Study Sites	12.15	13.33	12.18	18.72	13.35	826
All Other Sites	87.85	86.67	87.82	81.28	26.65	5360
N	434	1860	2467	599	6186	

recipients were not asked to report fish sizes nor number of returned fish. Return rates varied from 20 to 25 percent with a total of about 4,000 returns annually.

The total number of days fished and the total harvest by resident anglers were estimated from the information provided on the questionnaire. Harvest/day (HPUE) was calculated by dividing total harvest by total days fished. The total number of anglers was determined from license sales. Annual harvest and effort were estimated by multiplying the number of anglers who fished by the number of fish harvested and days fished. For this report, the 1988-89, 1989-90, and 1990-91 license years were included. In the mail survey, no estimate was made of number of hours fished. To compare hourly harvest rate and total effort in hours, an estimate of hours/day fished at each site was made from the creel survey. This estimate, therefore, includes elements of both the mail and the creel survey. It was useful primarily for analyzing causes behind the differences in total harvest estimated by telephone and mail surveys.

The standard error of the mean was used to represent variation for reported data. The statistical significance of differences among surveys, sites and years was approximated from the sum of the standard errors. The difference was considered significant when twice the sum of the standard errors (about a 95 percent confidence interval) was less than the difference between the two means.

RESULTS

CPUE, CPUE, and RPUE

Similar estimates of HPUE were made from telephone and mail surveys at the creel study sites (Table 3). Telephone estimates exceeded mail estimates in 5 of 12 comparisons with no consistent indication that statistically significant differences existed between mail and telephone estimates based on standard error of the mean and the observed difference.

Telephone survey estimates of HPUE were greater than creel survey estimates in 9 of 12 comparisons, and were significantly greater than creel survey estimates in 6 of 12 comparisons. In only one instance, at Clayton Lake, was the creel survey result significantly greater than the telephone survey result. Telephone reported rates at the large reservoirs (Heron, Bluewater, and Eagle Nest) were consistently greater than creel survey results. They were not consistently greater at the small lakes including Lower Charette, Clayton and Fenton. The lakes with the greatest consistent differences were larger and were fished mostly from boats. Differences in estimated HPUE (Table 3) generally were consistent within the large sites and were less consistent among the smaller sites with lower telephone sample size.

Although mail survey estimates of HPUE exceeded creel estimates at 8 of 12 sites, only 2 of 12 sites were judged to have significantly higher estimates of HPUE. The two sites with

Table 3. Comparison of estimated annual mean HPUE (number/hour) (SE) for resident anglers at northern New Mexico lakes in license years 1988-91 as estimated by creel, telephone and mail surveys.

Site	1988-89	1989-90	1990-91
Bluewater Lake			
Creel	0.293 (0.0340)	-----	-----
Telephone	0.518 (0.0634)	0.514 (0.1403)	0.474 (0.0779)
Mail[1]	1.559 (0.0634)	-----	-----
Heron Lake			
Creel	0.292 (0.0260)	-----	-----
Telephone	1.112 (0.2609)	0.725 (0.1183)	1.098 (0.2384)
Mail	1.475 (0.0830)	-----	-----
L.Charette Lake			
Creel	-----	0.600 (0.0520)	0.600 (0.0520)
Telephone	0.445 (0.1824)	0.892 (0.4034)	1.758 (0.2003)
Mail	-----	0.797 (0.3345)	1.838 (0.5640)
Clayton Lake			
Creel	-----	0.258 (0.0340)	0.247 (0.0340)
Telephone	0.285 (0.1336)	0.139 (0.1090)	0.0 (0.0)
Mail	-----	0.333 (0.1202	0.078 (0.0733)
Eagle Nest Lake			
Creel	0.411 (0.0300)	0.306 (0.0360)	0.389 (0.0360)
Telephone	0.815 (0.1468)	0.903 (0.2302)	0.800 (0.1504)
Mail	0.357 (0.0912)	0.391 (0.1188)	0.336 (0.0775)

Table 3. (cont'd.)

Site	1988-89	1989-90	1990-91
Fenton Lake			
Creel	0.148 (0.0160)	0.161 (0.0160)	0.149 (0.0160)
Telephone	0.465 (0.1850)	0.168 (0.0709)	0.145 (0.0493)
Mail	0.214 (0.0611)	0.350 (0.1024)	0.265 (0.0783)

[1] Mail survey days were converted to hours by using creel survey estimates of hours/day.

higher estimates were large sites, but the results were inconsistent because mail survey estimates at Eagle Nest Reservoir were similar to creel estimates of HPUE. The tendency toward higher estimates at large sites, therefore, was less certain than for telephone survey results.

The telephone-estimated mean site HPUE (0.64/hour) for all creel surveyed sites was 2.00 times the creel-estimated mean site HPUE (0.32/hour). The mail-estimated mean harvest rate (with creel estimated in hours/day) for all creel sites (0.67/hour) was 2.07 times the creel-estimated mean harvest rate and was virtually the same as the mean telephone estimate. The telephone-estimated mean (0.83/hour) at the three large lakes averaged 2.45 times the creel survey mean estimate (0.34/hour) while the three smallest lakes in the telephone survey (0.51/hour) averaged 1.65 times the creel survey estimate (0.31/hour). The mail estimates for the three large lakes (0.82/hour) averaged 2.44 times the creel survey mean while the three smallest lakes in the mail survey (0.55/hour) averaged 1.78 times the creel survey mean.

The creel survey estimated hours fished per outing were consistent among years at each site and varied little among sites (Table 4). Large Heron Reservoir had longer fishing days than small Fenton Lake, but the differences otherwise were not statistically significant. Anglers may have fished large lakes slightly longer than small lakes. The length of fishing days reported in creel surveys at small Lower Charette, Clayton and

Table 4. Hours fished/day/angler (SE) estimated for resident anglers at northern New Mexico lakes, in license years 1988-90 as estimated by creel surveys and telephone surveys.

Site	1988-89		1989-90		1990-91[1]
	Creel	Phone	Creel	Phone	Creel
Bluewater	4.75 (0.31)	5.82 (0.42)	-----	7.31 (0.52)	-----
Heron	5.11 (0.23)	4.63 (0.61)	-----	4.93 (0.68)	-----
L.Charette	-----	6.25 (1.91)	4.84 (0.24)	5.27 (1.44)	4.90 (0.24)
Clayton	-----	6.67 (1.56)	4.51 (0.28)	5.00 (1.91)	4.28 (0.28)
Eagle Nest	4.62 (0.17)	5.73 (0.72)	4.72 (0.17)	6.03 (0.73)	4.64 (0.17)
Fenton	4.29 (0.16)	4.86 (0.81)	4.25 (0.16)	5.03 (0.80)	4.31 (0.16)

[1] The telephone survey question about last trip length in days was left out after 1989-90. Fenton reservoirs averaged shorter days (4.48 hours) than the mean length of fishing days (4.76 hours) reported at large Bluewater, Heron and Eagle Nest reservoirs. Telephone-estimated hours/day fished averaged 1.15 times (40 minutes longer than) the creel-estimated hours/day fished, but variation precluded determining any significant differences.

The CPUE estimated in creel and telephone surveys (Table 5) differed significantly (no CPUE data were collected in the mail survey). Telephone estimates (1.05/hour) averaged 2.35 times the creel estimates (0.45/hour); similar to the difference in HPUE. Greater telephone estimates consistently occurred at all sites and years. Unlike HPUE estimates, telephone reports of CPUE did not appear to be related to lake size. Telephone-reported RPUE (Table 6) averaged 2.49 times the mean creel estimate. Both telephone and creel estimates of fish return were based on recall; no direct observations were made of the returned fish at the creel sites. Creel-surveyed anglers reported a mean fish-return fraction of 26.2 percent while telephone-surveyed anglers reported a mean return fraction of 43.2 percent. Variation was too great to determine if the difference was significant. There was little evidence, therefore, that telephoned anglers reported a greater fraction of returned fish on the last trip compared to anglers interviewed on site.

Most fish harvested at the study lakes were salmonids (Table 7). Rainbow trout (Oncorhynchus mykiss) comprised the great majority of trout harvested. At Bluewater and Heron reservoirs, kokanee salmon contributed most to the non-trout estimate. Channel catfish (Ictalurus punctatus), centrarchids, yellow perch (Perca flavescens) and walleye (Stizostedion vitreum) contributed most to the non-trout category otherwise. The telephone survey estimated higher trout HPUE in 9 of 12 comparisons with creel survey estimates and estimated higher non-trout HPUE in 7 of 12

Table 5. Comparison of estimated annual mean CPUE (number/hour) (SE) for resident anglers at northern New Mexico lakes in license years 1988-90 as estimated by creel and telephone surveys.

Site	1988-89	1989-90	1990-91
Bluewater			
Creel	0.348 (0.0003)	-----	-----
Telephone	0.769 (0.1027)	0.933 (0.2195)	0.893 (0.1272)
Heron			
Creel	0.345 (0.0003)	-----	-----
Telephone	1.315 (0.2597)	0.991 (0.1595)	1.301 (0.2430)
L.Charette			
Creel	-----	0.922 (0.0006)	0.930 (0.0006)
Telephone	0.7782 (0.2313)	1.989 (0.8940)	2.149 (0.2186)
Clayton			
Creel	-----	0.399 (0.0037)	0.379 (0.0042)
Telephone	0.310 (0.1401)	0.778 (0.2994)	0.667 (0.6667)
Eagle Nest			
Creel	0.482 (0.0001)	0.375 (0.0001)	0.532 (0.0001)
Telephone	0.981 (0.1676)	1.232 (0.3154)	1.274 (0.2448)
Fenton			
Creel	0.207 (0.0002)	0.224 (0.0002)	0.203 (0.0002)
Telephone	0.895 (0.3952)	0.240 (0.0817)	0.333 (0.1222)

Table 6. Comparison of estimated annual mean RPUE (number/hour) (SE) for resident anglers at northern New Mexico lakes in license years 1988-90 as estimated by creel and telephone surveys.

Site	1988-89	1989-90	1990-91
Bluewater			
Creel	0.055 (0.0060)	-----	-----
Telephone	0.252 (0.0786)	0.373 (0.0956)	0.419 (0.0919)
Heron			
Creel	0.053 (0.0100)	-----	-----
Telephone	0.203 (0.0605)	0.265 (0.0885)	0.203 (0.0610)
L.Charette			
Creel	-----	0.322 (0.0660)	0.329 (0.0660)
Telephone	0.334 (0.1233)	1.097 (0.5520)	0.390 (0.1779)
Clayton			
Creel	-----	0.140 (0.0340)	0.131 (0.0340)
Telephone	0.025 (0.0250)	0.639 (0.3310)	0.667 (0.6667)
Eagle Nest			
Creel	0.072 (0.0140)	0.069 (0.0140)	0.143 (0.0140)
Telephone	0.166 (0.0686)	0.329 (0.1134)	0.474 (0.1153)
Fenton			
Creel	0.059 (0.0320)	0.063 (0.0320)	0.054 (0.0320)
Telephone	0.430 (0.2545)	0.072 (0.0378)	0.188 (0.0832)

Table 7. Annual mean HPUE (number/hour) (SE) for trout and non-trout species for lakes in northern New Mexico as measured by creel, telephone and mail surveys.

	88-89		89-90		90-91	
Site	Trout	Non-Trout	Trout	Non-Trout	Trout	Non-Trout
Bluewater Lake						
Creel	0.262 (0.020)	0.029 (0.010)	-----	-----	-----	-----
Telephone	0.428 (0.059)	0.090 (0.028)	0.522 (0.142)	0.053 (0.022)	0.450 (0.538)	0.024 (0.020)
Mail[1]	1.460 (0.060)	0.099 (0.007)	-----	-----	-----	-----
Heron						
Creel	0.052 (0.008)	0.244 (0.028)	-----	-----	-----	-----
Telephone	0.226 (0.065)	0.886 (0.267)	0.214 (0.062)	0.511 (0.120)	0.311 (0.150)	0.787 (0.208)
Mail	0.326 (0.018)	1.150 (0.074)	-----	-----	-----	-----
Charette Lake						
Creel	-----	-----	0.485 (0.046)	0.086 (0.018)	0.479 (0.046)	0.085 (0.018)
Telephone	0.225 (0.160)	0.220 (0.148)	0.858 (0.416)	0.033 (0.033)	1.458 (0.203)	0.300 (0.228)
Mail	-----	-----	0.507 (0.188)	0.290 (0.215)	0.815 (0.178)	1.023 (0.456)

Table 7. (cont'd.)

Site	88-89		89-90		90-91	
	Trout	Non-Trout	Trout	Non-Trout	Trout	Non-Trout
<u>Clayton Lake</u>						
Creel	-----	-----	0.092 (0.012)	0.229 (0.032)	0.099 (0.012)	0.182 (0.032)
Telephone	0.285 (0.134)	0.000 (0.000)	0.139 (0.109)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Mail	-----	-----	0.142 (0.054)	0.191 (0.084)	0.051 (0.045)	0.026 (0.029)
<u>Eagle Nest</u>						
Creel	0.352 (0.030)	0.095 (0.018)	0.266 (0.026)	0.087 (0.018)	0.307 (0.026)	0.083 (0.018)
Telephone	0.416 (0.116)	0.399 (0.112)	0.559 (0.144)	0.343 (0.142)	0.585 (0.121)	0.215 (0.066)
Mail	0.230 (0.064)	0.127 (0.040)	0.215 (0.053)	0.176 (0.090)	0.252 (0.062)	0.084 (0.027)
<u>Fenton</u>						
Creel	0.196 (0.022)	0.012 (0.002)	0.209 (0.022)	0.011 (0.002)	0.184 (0.022)	0.010 (0.002)
Telephone	0.465 (0.185)	0.000 (0.000)	0.097 (0.039)	0.071 (0.063)	0.145 (0.049)	0.000 (0.000)
Mail	0.213 (0.061)	0.001 (0.002)	0.328 (0.098)	0.022 (0.027)	0.265 (0.078)	0.000 (0.000)

[1] Mail survey days were converted to hours by using creel survey estimates of hours/day.

comparisons. Although there is some indication that non-trout were under-reported compared to trout, the differences can be partly ascribed to low sample size for the telephone surveys at small lakes. At Heron and Eagle Nest reservoirs, where fish other than trout were common and sample size was relatively large, the telephone survey estimated a larger non-trout HPUE just as it did for trout. Mail survey estimates of both non-trout and trout HPUE were higher than creel estimates in 8 of 12 comparisons. The results generally indicate similar differences in survey results for both trout and non-trout species, although there is substantial variation among the sites.

Annual Harvest, Catch, Return and Effort

With one exception at Fenton Lake, the telephone survey consistently estimated greater annual harvest than was estimated by the creel survey. The telephone estimate of total harvest summed over all sites was 3.0 times the total annual harvest estimated by the creel survey (Table 8). The mean site ratio ofcreel and telephone estimated harvest was 2.5 and ranged between 1.79 and 4.72. Based on standard errors, the telephone survey estimates of annual harvest at each site often were significantly higher than the creel survey estimates (Table 8), especially at Eagle Nest and Fenton reservoirs. The mail survey estimate of total annual harvest at all creel sites was 1.2 times the creel survey estimate and none of the differences were clearly significant based on standard errors. The mean ratio of mail and creel survey harvest estimates was 1.4 and ranged between 0.32 and 3.06. The estimates

Table 8. Annual total fish harvest (SE) by resident anglers estimated from creel, telephone and mail surveys at lakes in northern New Mexico during license year 1988-1990.

Site	1988-89	1989-90	1990-91
L.Charette Lake			
Creel	-----	24,763 (2,528)	25,304 (2,705)
Telephone	63,849 (15,485)	63,489 (15,397)	55,877 (13,552)
Mail	42,872 (13,192)	32,891 (9,895)	77,493 (36,090)
Clayton Lake			
Creel	-----	6,517 (6,531)	5,706 (6,665)
Telephone	11,752 (4,665)	11,686 (4,639)	10,285 (4,083)
Mail	6,985 (3,269)	8,393 (4,478)	1,807 (1,143)
Eagle Nest			
Creel	206,418 (21,128)	118,353 (14,732)	155,410 (15,392)
Telephone	561,707 (57,551)	558,545 (57,228)	491,574 (50,381)
Mail	179,376 (23,438)	150,842 (26,471)	134,146 (17,181)
Fenton Lake			
Creel	32,418 (4,106)	37,741 (5,114)	28,075 (3,770)
Telephone	67,644 (12,396)	67,263 (12,327)	59,198 (10,849)
Mail	46,979 (7,507)	81,874 (18,137)	50,009 (11,769)
Other			
Telephone	8,506,493 (133,077)	8,458,617 (132,345)	7,444,396 (117,639)

generally were consistent among years within sites in the creel and telephone surveys. The mail survey results were less consistent, but high variation precluded identifying significant changes.

Total annual fish catch estimated by the telephone survey for all creel sites summed together was 3.5 times the creel estimate (Table 9). Telephone estimates were larger than creel estimates at all sites, and significantly so at most sites. The mean site ratio of annual catch estimated by telephone and creel surveys was 2.8.

The telephone estimate of total return summed over all sites (Table 10) was disproportionally higher than the creel estimate (5.2 times). Differences were consistently significant at Lower Charette and Eagle Nest reservoirs. The mean site ratio of telephone and creel returns averaged 4.2 and ranged between 1.90 and 10.34. The wide variation may reflect the relative size distribution of fish present at the sites as well as sampling error. The total annual angler effort at each site estimated by the telephone survey consistently was greater than the creel survey estimate, but was significantly so only at Eagle Nest Reservoir, where telephone sample size was relatively large. The telephone estimate of total hours fished summed over all creel sites was 1.6 times the creel survey estimate. The mean site ratio of telephone and creel estimates of annual effort was 1.6 and ranged between 1.14 and 2.14. Although most of the contribution to higher total estimated harvest came from the harvest success/hour, higher estimated annual effort also contributed significantly. Estimated effort by both methods generally was consistent over years within sites and changes over time could not be identified with the

Table 9. Annual total fish catch (SE) by resident anglers estimated from creel, telephone and mail surveys at lakes in northern New Mexico during license years 1988-1990.

Site	1988-89	1989-90	1990-91
L.Charette Lake			
Creel	-----	38,060 (3,413)	39,182 (3,679)
Telephone	108,342 (26,135)	107,732 (25,988)	94,814 (22,873)
Clayton Lake			
Creel	-----	10,058 (8,266)	8,735 (8,177)
Telephone	18,543 (7,383)	18,438 (7,341)	16,227 (6,461)
Eagle Nest			
Creel	242,380 (22,009)	144,814 (15,500)	212,395 (17,624)
Telephone	837,017 (86,492)	832,306 (86,005)	732,509 (75,714)
Fenton Lake			
Creel	45,422 (6,471)	52,410 (7,757)	38,283 (5,647)
Telephone	108,003 (19,717)	107,395 (19,606)	94,518 (17,257)
Other			
Telephone	16,136,039 (242,884)	16,045,223 (241,550)	14,121,339 (214,878)

Table 10. Annual total fish returns (SE) by resident anglers estimated from creel, telephone and mail surveys at lakes in northern New Mexico during license year 1988-1990.

Site	1988-89	1989-90	1990-91
L.Charette Lake			
Creel	-----	13,297 (2,293)	13,878 (2,494)
Telephone	44,493 (11,223)	44,243 (11,160)	38,938 (9,822)
Clayton Lake			
Creel	-----	3,541 (5,067)	3,029 (4,738)
Telephone	6,790 (3,885)	6,752 (3,863)	5,942 (3,400)
Eagle Nest			
Creel	35,962 (6,448)	26,461 (4,818)	56,985 (8,584)
Telephone	275,310 (33,189)	273,761 (33,002)	240,936 (29,051)
Fenton Lake			
Creel	13,004 (5,002)	14,669 (5,833)	10,208 (4,204)
Telephone	40,359 (10,394)	40,132 (10,336)	35,320 (9,097)
Other			
Telephone	7,663,123 (122,505)	7,619,994 (121,830)	6,706,327 (108,247)

existing variation.

The difference between mail and telephone survey estimates of total annual harvest (Table 8), total annual catch (Table 9) and total annual return (Table 10) was due mostly to the lower number of annual angling hours estimated in the mail survey (Table 11), assuming that a mail survey day was the same length in hours as a creel survey day at the same site. Mail survey estimates of annual fishing effort were lower than telephone estimates at every site. Although the mail HPUE and telephone HPUE estimates were similar (Table 3), the mail-estimated time fished averaged about half that estimated by the telephone survey. The telephone survey estimated greater annual fishing effort than the creel survey in 7 of 10 trials. The telephone estimates were lower only at Eagle Nest Lake and were consistently higher at Lower Charette, Clayton and Fenton lakes. The mail survey estimate was smaller than the creel survey estimate at 7 of 10 sites analyzed. The variance in estimated creel hours was too high, however, to identify significant differences. The mean ratio of mail and creel estimated annual effort was 0.75 and ranged between 0.48 and 1.37.

In 9 of 10 comparisons, the number of trips/year estimated by the creel survey was greater than the telephone survey estimates. The total trips estimated by the creel survey exceeded the total trips estimated by the telephone survey by a factor of 1.16. None of the differences were clearly significant (Table 12). These results indicate that the higher telephone estimates of effort were caused by higher estimates of trip length rather than the estimated number of trips/year. Estimates of total fish harvested in trout

Table 11. Comparison of estimated annual total hours fished (SE) for resident anglers at northern New Mexico lakes in license years 1988-1990 as estimated by creel, telephone and mail surveys.

Site	1988-89	1989-90	1990-91
L.Charette Lake			
Creel	-----	41,283 (3,743)	42,155 (3,725)
Telephone	88,735 (21,018)	88,235 (20,900)	77,655 (18,395)
Mail	-----	33,401 (9,166)	56,031 (16,295)
Clayton Lake			
Creel	-----	25,222 (10,448)	23,064 (10,390)
Telephone	44,659 (11,982)	44,407 (11,915)	39,083 (10,487)
Mail	-----	34,506 (14,367)	13,332 (4,690)
Eagle Nest			
Creel	502,797 (46,777)	386,305 (31,983)	399,101 (34,168)
Telephone	785,484 (77,584)	781,063 (77,148)	687,411 (67,919)
Mail	240,799 (27,995)	190,995 (21,865)	205,269 (22,237)
Fenton Lake			
Creel	219,080 (19,967)	233,795 (21,974)	188,999 (18,220)
Telephone	268,028 (33,103)	266,520 (32,917)	234,563 (28,975)
Mail	129,575 (20,366)	152,881 (22,432)	131,714 (16,665)
Statewide			
Telephone	17,730,589 (256,555)	17,630,799 (255,138)	15,516,798 (226,367)

Table 12. Total number of trips/year (SE) taken by all anglers at northern New Mexico sites as estimated by creel and telephone surveys in license years 1988-1990.

Site	1988-89	1989-90	1990-91
L.Charette Lake			
Creel	-----	8,531 (692)	8,601 (688)
Telephone	8,295 (1,925)	8,249 (1,914)	7,260 (1,685)
Clayton Lake			
Creel	-----	5,586 (1,933)	5,384 (1,883)
Telephone	5,484 (1,414)	5,454 (1,406)	4,800 (1,237)
Eagle Nest			
Creel	108,871 (10,142)	81,894 (6,416)	86,037 (7,242)
Telephone	90,076 (8,613)	89,569 (8,565)	78,830 (7,541)
Fenton Lake			
Creel	51,014 (4,524)	54,974 (4,967)	43,870 (4,170)
Telephone	38,085 (4,533)	37,871 (4,507)	33,330 (3,967)
Other			
Telephone	1,702,952 (23,112)	1,693,367 (22,986)	1,490,326 (20,498)

and non-trout categories (Table 13) revealed the same relative differences as the estimates for harvest rate. Errors apparently were associated with both telephone survey and mail survey estimates of the HPUE and annual fishing effort. Assuming the creel survey results were accurate, the telephone survey overestimated both harvest rate and annual angler effort. The mail survey overestimated harvest rate, underestimated annual angler effort, and correctly estimated the annual harvest.

Table 13. Total trout and non-trout harvest (SE) by resident anglers at lakes in northern New Mexico in license years 1988-1990

	1988-89		1989-90		1990-91	
Site	Trout	Non-Trout	Trout	Non-Trout	Trout	Non-Trout
Charette Lake						
Creel	-----	-----	20,024 (2,511)	3,549 (840)	20,189 (2,517)	3,579 (845)
Telephone	37,957 (9,207)	25,891 (7,137)	37,744 (9,155)	25,746 (7,097)	33,218 (8,058)	22,659 (6,246)
Mail	34,709 (12,509)	8,163 (2,832)	20,910 (5,280)	11,981 (7,084)	34,352 (9,475)	43,140 (29,037)
Clayton Lake						
Creel	-----	-----	2,328 (4,612)	5,770 (3,238)	2,295 (4,939)	4,195 (3,210)
Telephone	10,708 (3,477)	1,045 (3,050)	10,647 (3,457)	1,039 (3,033)	9,371 (3,043)	914 (2,669)
Mail	4,908 (2,088)	2,078 (1,428)	3,587 (2,081)	4,806 (3,097)	1,197 (699)	610 (456)
Eagle Nest						
Creel	177,165 (20,993)	47,753 (6,187)	102,894 (12,711)	33,478 (5,648)	122,367 (13,921)	33,137 (4,719)
Telephone	395,412 (39,765)	166,295 (23,795)	393,186 (39,542)	165,359 (23,661)	346,042 (34,811)	145,532 (20,827)
Mail	115,599 (16,690)	63,777 (10,392)	83,003 (10,346)	67,839 (19,871)	100,734 (14,143)	33,412 (5,655)

Table 13. (cont'd.)

	1988-89		1989-90		1990-91	
Site	Trout	Non-Trout	Trout	Non-Trout	Trout	Non-Trout
Fenton						
Creel	42,871	2,648	48,870	2,639	34,801	1,837
	(5,608)	(518)	(6,766)	(558)	(4,623)	(385)
	61,960	5,684	61,611	5,652	54,223	4,975
Telephone	(9,269)	(8,102)	(9,217)	(8,057)	(8,113)	(7,091)
Mail	46,741	237	76,690	5,184	50,009	0
	(7,478)	(235)	(17,480)	(4,866)	(11,769)	0
Other						
	4,171,596	4,332,561	4,148,118	4,308,176	3,650,742	3,791,609
Telephone	(68,991)	(81,679)	(68,611)	(81,226)	(60,924)	(71,978)

DISCUSSION

Differences in Sampled Angler Populations

A potentially complicating factor in this research was the propensity of angler parties interviewed in creel surveys to pool their harvest so that individual HPUE was impossible to confirm. In the initial creel survey design, anglers were expected to report their individual HPUE, fishing effort and ages so that the success and effort of the same age groups could be compared among the three surveys. Because of the angler party effect in creel surveys, the harvest by young anglers could not be sorted from that of anglers age 12 and older, included in the mail survey, and anglers age 14 and over, included in the telephone survey. Assuming no other source of variation, we expected the creel survey to estimate the highest total angler effort and harvest and the telephone survey to estimate the lowest total effort and harvest.

Based on the fraction of New Mexico residents aged 9 (an age judged to be near the lower limit of angler effectiveness) through 13, we did not expect the potential difference in total harvest estimated by the creel and the telephone survey to exceed 10 percent, as long as children do not fish disproportionally more than older age groups. Cole et al. (1992b) reported that the number of children in households with anglers, was nearly identical to the number of children in households without anglers, indicating that there was not a disproportionally high fraction of anglers among children in New Mexico. A 10 percent error falls well within the range of statistical uncertainty demonstrated by the data. The telephone estimate of total annual harvest was 300 percent higher than the creel estimate at the creel sites. A 10 percent error was insignificant compared with the differences observed in mail and telephone survey results.

The mail survey estimate of total harvest per year was closer to the creel estimate (about 120 percent of the creel estimate) and the 6 percent smaller population included in the mail survey could have had a small effect on the difference observed between mail and creel surveys. Once again, however, the error falls well within the range of statistical uncertainty and is small in comparison to the observed differences.

The HPUE estimated by the mail and telephone surveys would be slightly elevated over the creel estimate, if young anglers have a much lower HPUE than older anglers. The HPUE would be maximally reduced by 10 percent if children fished just as effectively as older anglers and harvested no fish. A 10 percent error in the estimated HPUE would explain a minor part of differences observed among the creel, telephone (200 percent higher than the creel survey), and mail (208 percent higher than the creel survey) surveys. The differences in the sizes of the angler populations sampled by the three survey methods were concluded to be insignificant factors in determining the observed estimate.

Creel Survey Accuracy

A primary reason for this research, the evaluation of mail and telephone survey accuracy by comparison to creel survey results, relies on the accuracy of the creel survey results at the six New

Mexico lakes. Several complications could cause HPUE to be underestimated using the creel survey. When asked, anglers could deny any harvest success in order to avoid departure delay or to avoid penalty for breaking fishing regulations. This was believed to be a minor source of error, but the creel clerks had no authority to check. For boat anglers, the whole party's harvest typically was aggregated in a cooler or other container, and harvest rate was estimated by dividing the party number of hours fished by the total harvest. The harvest rate would be underestimated if any party member did not fish the full time reported for the entire party. The hours fished during the outing were estimated by the reported time that the whole party started fishing and the reported time that they stopped fishing. Although the creel clerks probed to make certain all anglers fished, they could not actually confirm they all fished uniformly as was generally indicated. Some parties may have reported more than actual party participation to keep harvest within legal limits. Because of these possible errors, creel survey underestimation of HPUE was more likely than overestimation.

One possible cause of overestimation is recall of fishing starting times later than actually occurred or recall of fishing stopping times earlier than actually occurred. Phippen and Bergersen (1991) indicated that anglers provide imprecise estimates of actual fishing time, but the error in their estimates was relatively small and not obviously biased. Therefore, this possible source of error in the creel survey was not thought to be important.

Creel survey estimates of RPUE were not verified by observation. Therefore, the estimated return rate of fish suffers from recall errors as does the telephone survey, but the short-time lapse should minimize the exaggeration of success rate that appears to occur as the lapsed time increases (Chu et al. 1989, Tarrant et al. 1993). Underestimation could occur, however, if one person was most involved in the interview and reported only his/her own return rate while neglecting return rates of others. The amount of error of this kind may have depended on the care taken by creel clerks in separating individual and party behaviors.

Sources of Variation Among Surveys

Most of the potential for error at creel survey sites rested with the care taken by creel clerks, who were made aware of the importance of each bit of information. Telephone and mail surveys are more likely than creel surveys to overestimate success and effort because angler reports tend to be exaggerated as the time increases between activity and interview. Chu et al.(1989) indicated that both number of trips and success tended to be overestimated, but that short trips often went unreported. Tarrant et al. (1993) found that recall bias was related to respondence behavior. Respondents increased estimates of days fished with increasing length of recall period and nonrespondents decreased estimes of days fished with increasing recall period. The success rate will be elevated if success is overestimated more than effort, as it would be if highly successful trips are more likely to be remembered than less successful trips. Determining the cause of the higher telephone estimates of effort and HPUE may help improve survey design.

The difference in the total annual hours fished estimated in telephone and creel surveys was an important contribution to the higher estimated total annual harvest and catch in the telephone survey. The similarity in number of trips estimated in creel and telephone surveys indicates that anglers recalled the number of trips accurately, within the limits of uncertainty associated with the data, assuming that the creel survey data were accurate. This result contradicts the general rule that recall errors increasingly overestimate success and effort with increased time lapsed between the interview and the activity (Chu et al. 1989, Tarrant et al. 1993). The higher telephone estimate of total annual effort was caused mostly by the estimated total length of trip. The average length of an angler day reported by telephone was only slightly longer (1.15 times) than the creel estimate, thus most of the error seemed to be associated with the total hours and days recalled for the last trip. This could be caused by the time-lag effect described by Chu et al. (1989) and Tarrant et al. (1993), but other explanations are possible.

Any propensity of telephoned anglers toward rounding parts of days fished to whole angler days could introduce error to the estimate of effort on the last trip. Telephone respondents also may have included fishing-related activities (e. g., rigging, clean up, boat ramp time) in the estimate of total time fished.

The major cause of high telephone-estimated annual harvest was the high estimate of HPUE. This too could have been exaggerated by time-lag effects reported by Chu et al. (1989) and Tarrant et al. (1993), but another explanation is possible. Telephoned anglers who fished in parties may have reported the party catch and harvest instead of their own, despite a request to recall their own harvest and return. The telephone survey did not probe to assure that the reported catch was not a party catch. Higher telephone estimates with respect to creel estimates were most often associated with larger sites where many boating parties were common (Eagle Nest, Bluewater, and Heron). Reported outing length in hours typically was the same for each individual in the entire party. Dividing a party HPUE catch by the length of fishing time for one person inflates estimated individual HPUE by the number in the party. The telephone survey needs to be modified to probe further about party size and success in order to evaluate this hypothesis. Similar confusion between personal and party success could exist for any type of remotely administered survey.

Mail survey results were not as clearly affected by lake size, and party size was a less probable single cause for high estimates of HPUE. Based on previous research results (Brown and Wilkins 1978), we expected high mail estimation of both the HPUE and the total harvest because avid anglers are more likely to be included in surveys with low response. Brown and Wilkins (1978) indicated that even a response rate of 70 percent resulted in avidity bias. Because 20 to 25 percent of the surveyed anglers returned the mail surveys, the survey results have a high probability of bias due to angler avidity. The high HPUE may have accurately represented the avid angler success while they totally forgot certain trips of similar success. Alternatively, they may have remembered more of the highly successful trips and forgotten the less successful trips. Either scenario, or a combination of the two, could explain the observed result. If the latter hypothesis is correct, and respondents to the mail survey preferentially left out zero success days, further analysis of the mail surveyed anglers should reveal a relatively low frequency of zero reported HPUE.

Weithman and Haverland (1991) dealt with angler recall problems by contacting anglers in advance of the telephone surveys to have them keep detailed records. Comparisons with simultaneous roving creel surveys revealed only 20 percent greater telephone estimate of harvest and annual effort compared to a 320 percent greater telephone estimate of harvest and 160 percent greater telephone estimate of annual effort observed in this study. Weithman and Haverland (1991) did not discuss which of their surveys was more accurate.

Future Applications and Research

The information provided by this study revealed new insight about the accuracy and precision of survey methods used in New Mexico. The difficulties associated with conducting accurate and precise surveys is amply demonstrated by Guthrie et al. (1991), Urquhart et al. (1993) and this study. Surveys of angler success and effort provide such essential management information that continued survey improvement is of unquestioned value. Although problems remain to be resolved with surveying methodology, this study points the way to their solution.

The general consistency of results over the creel survey sites provides confidence that study conclusions can be extended over those mail and telephone domains that include similar situations. The creel survey sites were most representative of cold-water reservoir fisheries in northern New Mexico and may not represent the results obtained at warm-water or stream sites. Further survey analysis is needed to reduce the uncertainty associated with other New Mexico conditions. Future statewide surveys would be improved by simultaneously conducting creel surveys at sites selected to expand representation of conditions elsewhere in New Mexico.

The results presented here support the conclusion that past mail survey estimates of harvest are "realistic" and useful for accurately representing past harvest rates. The results may be used in fishing mortality and efficiency studies at sites where other fisheries data have been collected. The mail survey estimate of angler effort requires a correction factor that can be derived from this study's results. More accurate sport-fish catchability coefficients can be calculated to improve RIOFISH, the comprehensive fishery management model described by Cole et al. 1990, 1992a). Some doubt remains, however, because factors causing high HPUE and low annual effort are not understood. We must assume the effects of those factors have been constant over the duration of the mail survey to make use of the entire record for trend or other analysis.

The use of telephone data for estimating angler benefits in RIOFISH must be corrected to compensate for overestimating harvest success. These data can be used in future model refinement now that they are available. The most important correction factors are for the HPUE, CPUE, and annual effort because total annual harvest, catch and return are calculated from these data. Estimated multiplier correction factors derived from the mean site values are for HPUE, 0.50; for CPUE, 0.43; and for total annual effort, 0.63.

Creel survey estimates of HPUE likely will be the most accurate of the methods used as long as all anglers with fish are intercepted representatively and the time that they fished is carefully queried. The major potential source of error in point access surveys is incomplete sampling of all exit points (Hayne 1991). As long as the angler success is unrelated to departure point, the HPUE should remain unaffected. Total effort and harvest, however, will be underestimated to the extent that exit points are missed. To check for significant avoidance of creel surveys at departure points, future creel surveys may be improved by conducting checks with commissioned officers, who have the legal authority to see how many anglers avoid reporting fish harvested. Actual fishing behavior, determining the time fished, and fish returned can and should be checked by direct observation.

Although the precision of access-point surveys may be increased by use of a bus-route approach (Jones and Robson 1991) to count cars at access points, where many such access points exist, a roving creel survey may be preferred. Also, it may be advantageous to use roving creel surveys at low-use sites instead of access point surveys (Hayne 1991), as long as anglers can be effectively separated from non-anglers.

The results of this survey comparison beg a number of other research questions. Whether mail or telephone surveys are used, correction factors may be needed to estimate success and effort, if the biases observed in this study are not entirely resolved. The high consistency with which harvest rate was overestimated at larger sites indicates that appropriate correction factors may be site-size dependent.

Accurate statewide and regional estimates of angler HPUE and CPUE may require both a creel survey and a statewide telephone or mail survey, unless the apparently biased reporting of success rate can be resolved. The creel survey, if accurate, would be used to calibrate reported harvest rate and angler effort. Such creel surveys may need to be conducted at the most visited sites. An improved creel survey may require random and instantaneous angler counts.

Will a telephone survey be "better" for statewide surveys than a mail survey? Although these results suggest that mail-survey harvest estimates were more accurate than telephone estimates, at present we cannot determine why. It appears that mail estimates of annual harvest are more accurate as a consequence of compounded errors that result through some combination of angler avidity bias and relatively poor recall of time spent on at least certain trips. The HPUE is an important survey measure that was equally overestimated by mail and telephone surveys compared with creel survey estimates. The number of hours fished was not estimated in the mail survey, but should be to estimate HPUE more accurately than on an "angler day" basis. Mail surveys may be less expensive, even with follow-up calling to encourage higher returns, but the design of future mail surveys should incorporate elements more like the present telephone survey, thereby including new sources of error. Both telephone and mail approaches have enough unanswered questions about their performance that neither can be judged better at this time. Other previously mentioned research questions should be addressed before pronouncing the relative suitability of either technique for statewide surveys.

CONCLUSIONS

1. Results of mail, telephone and creel survey comparisons at six reservoirs in northern New Mexico indicate that past mail survey harvest estimates were reasonably accurate.

2. The results indicate that both mail and telephone surveys generate greater estimates of angler HPUE than are estimated by access-point creel surveys.

3. Compared to the creel survey, the telephone surveys estimated about the same number of trips and greater total effort. The difference in estimated annual effort is caused by a difference in estimated trip length.

4. Telephone estimates of annual harvest are higher than the creel survey estimates because of the combined effects of higher estimated HPUE and annual effort.

5. Mail survey estimates of total annual effort were lower than creel survey estimates; total harvest was similar, however, because HPUE was elevated.

6. Sources of error in survey techniques are incompletely understood. To develop more confidence in survey methodology, success and harvest assessments should be further researched and improved.

7. The most accurate methodology for assessing statewide angler success and effort probably will require both creel and statewide survey elements.

8. Creel surveys provided preliminary correction factors for both mail and telephone estimates of angler HPUE and annual harvest.

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