1984

Angler Harvest Survey of Lake Francis Case, South Dakota

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ANGLER HARVEST SURVEY OF

LAKE FRANCIS CASE, SOUTH DAKOTA

BY

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A Thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Wildlife and Fisheries Sciences
(Fisheries Option)

South Dakota State University
1984

ANGLER HARVEST SURVEY OF

LAKE FRANCIS CASE, SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ACKNOWLEDGMENTS

My sincere thanks go to Dr. R. L. Applegate and Dr. R. S. Benda for their help and encouragement during this study. Special thanks to Dr. C. G. Scalet, Dr. W. L. Tucker, P. D. Evenson, and W. G. Hovland for their assistance during the preparation of this thesis. In addition, thanks to Dr. R. L. Linder for being there when I needed him.

I would like to thank the following people for their assistance during the study: D. G. Unkenholz, South Dakota Department of Game, Fish and Parks, provided facilities and assistance at Lake Francis Case; D. Sly, Sly's Aerial Spraying, for his friendship and flying service; and creel clerks L. L. Sly, C. Roll, and T. R. St. Sauver.

Finally, very special thanks are extended to my parents, without whose understanding and moral support this thesis could not have been completed.

Financial assistance was provided by an Army Corps of Engineers subcontract through the South Dakota Department of Game, Fish and Parks (contract #DAWC 45-81-C-0091), and was conducted under the direction of the South Dakota Cooperative Fishery Research Unit.[1]

[1] Cooperating agencies: South Dakota Department of Game, Fish and Parks, South Dakota State University, and United States Fish and Wildlife Service.

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ANGLER HARVEST SURVEY OF LAKE FRANCIS CASE, SOUTH DAKOTA

Abstract

LAWRENCE M. MILLER

An angler harvest survey, consisting of two independent surveys, was conducted on Lake Francis Case, South Dakota, from May through October 1981, and April through October 1982. An aerial angler count was used to estimate angler pressure, and an angler interview survey was used to estimate catch rate. In 1981, a section of Lake Francis Case in the vicinity of the Gregory County Pump Storage Project (Zone 2) was surveyed. In 1982, the survey was expanded to include the entire reservoir (additional Zones 1 and 3). Estimated fishing pressure for Zone 2 in 1981 was 188,631 angler-hours and in 1982 it was 121,300. Total 1982 fishing pressure for the entire reservoir was 557,576 angler-hours. The estimated harvest in 1981 (Zone 2) was 57,910 fish and in 1982 it was 31,555 fish. Total 1982 harvest for the entire reservoir was 136,150 fish. The overall catch rate for Zone 2 in 1981 was 0.31 fish per angler-hour and in 1982 it was 0.29 fish per angler-hour. The catch rate for all zones combined in 1982 was 0.27 fish per angler-hour.

INTRODUCTION

In 1970, 29 million United States freshwater recreational anglers spent $3.7 billion in the pursuit of their sport. The 36 million anglers in 1980 spent more than twice that of the 1970 estimates ($8.8 billion). Freshwater fishing in the Unites States increased from 592 million angler days in 1980 to 711 million angler days in 1980 (U.S. Fish and Wildlife Service 1982). By the year 2000 fishing pressure is expected to exceed 900 million angler days (Prince and Maughan 1978). An estimated 55 - 60% of the projected pressure will take place on 1,300 large reservoirs (Jenkins 1970). The subsequent increased harvest of fishes will require that these resources be properly managed and conserved. In order to achieve this, accurate estimates must be obtained for the rate of stock depletion and production in terms of angler harvest.

Techniques for determining harvest by angler survey reached a fair degree of sophistication by the 1950s, but their use had generally been restricted to small bodies of water that could be covered in a short period of time (Forney 1980). On large open reservoirs, which are now common on all major river systems in the United States, counting anglers in a short period is difficult. Researchers in the past have suggested using aircraft to count anglers on large bodies of water (Eschmeyer et al. 1946; U.S. Fish and Wildlife Service 1952; Harrison 1956; Neuhold and Lu 1957). Schmidt (1975) implemented an aerial creel survey method on Lake Sharpe, South Dakota. The survey involved

adoption of an economically feasible and statistically accurate method of estimating fishing pressure and harvest on Missouri River mainstem reservoirs.

This study was initiated to conduct an aerial creel survey in the vicinity of the Army Corps of Engineers proposed Gregory County pump storage facility on Lake Francis Case, South Dakota. In 1982 the scope of the survey was expanded to include the entire Lake Francis Case reservoir. The study was designed to:

1. Estimate recreational angling pressure.
2. Estimate catch rates, mean party size, mean length of angler day, and residence of the anglers.
3. Combine the results of the above to estimate angler harvest.
4. Determine a feasible sampling design to be used in future creel surveys on Missouri River mainstem reservoirs.

STUDY AREA

Lake Francis Case was formed in 1952 by closure of the Fort Randall Dam located on the Missouri River 9.7 km (6 mi) south of Lake Andes, South Dakota (Fig. 1). The lake is one of six impoundments authorized by the Pick-Sloan Plan of the Flood Control Act of 1944 for development of the Missouri River basin. The lake has a drainage area of 424,030 km^2 (263,480 mi^2), a capacity of 703,110 hectare-meters (5.7 million acre-feet), a surface area of 41,000 hectares (102,000 acres), a shoreline of 870 km (540 mi), and extends 172 km (107 mi) upstream from Fort Randall Dam to Big Bend Dam near Fort Thompson, South Dakota (Army Corps of Engineers 1978).

The lake was divided into three zones. Zone 2 (Gregory County Pump Storage Project area) constituted a 44 km (27.5 mi) stretch of the reservoir in the vicinity of the Platte-Winner bridge on State Highway 44, 24 km (15.0 mi) west of Platte, South Dakota. This zone was bounded by Cedar Creek to the south and the Brule-Charles Mix county line to the north (Fig. 2) (river mile 907 - 935). Zone 1 extended up the reservoir from Zone 2 to the Big Bend Dam (river mile 935 - 987). Zone 3 extended down the reservoir from Zone 2 to Fort Randall Dam (river mile 880 - 907).

Each zone had several points of access to the water; boat launching facilities were generally limited to public access areas. In Zone 1 there were public boat ramps at the Fort Thompson, Chamberlain, Boyer, and Elm Creek recreation areas. Zone 2 had public launching facilities at the Buryanek, West Bridge Highway 44, Snake Creek, and

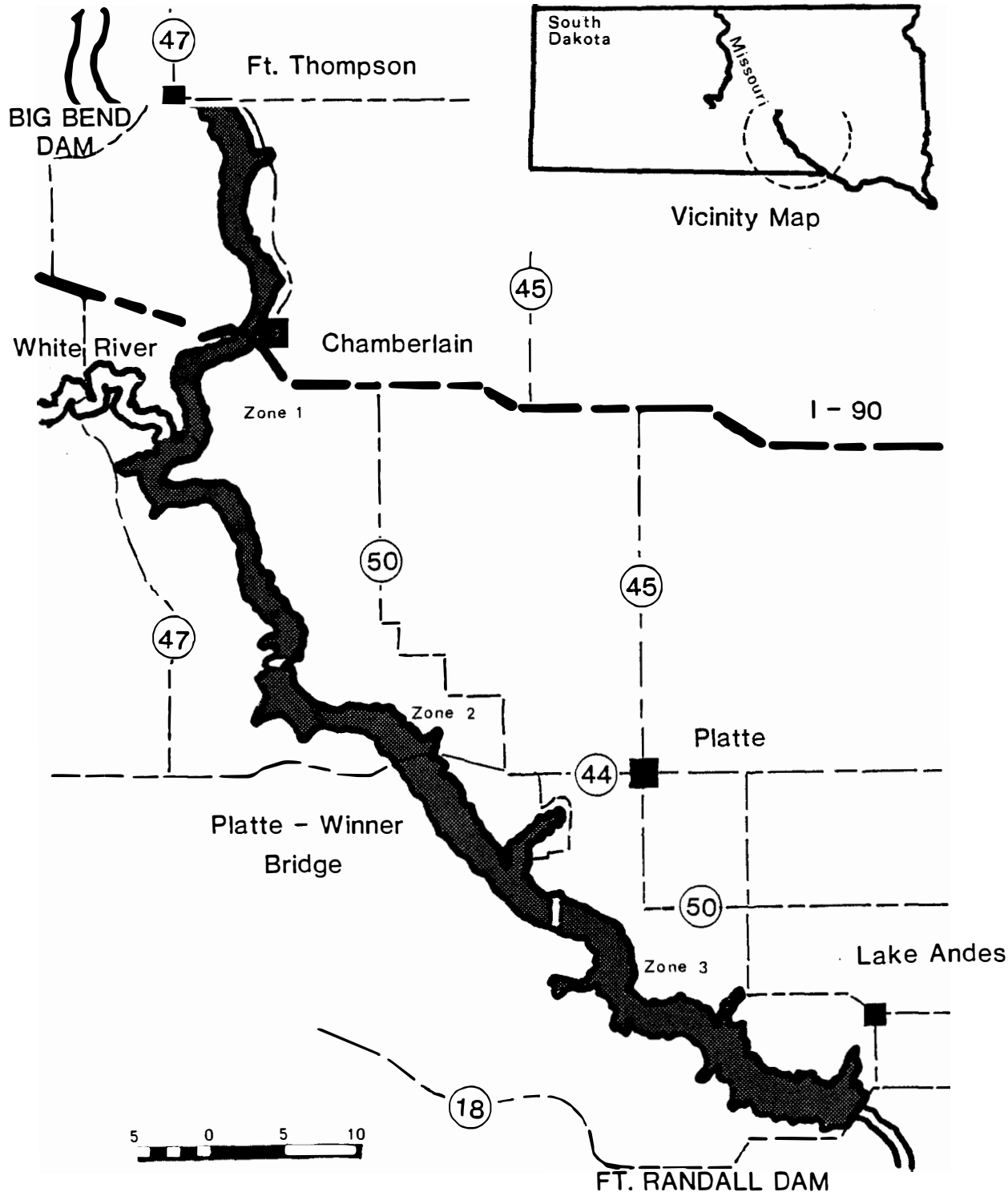

Figure 1. The Lake Francis Case study area, Zones 1 - 3, 1981 and 1982.

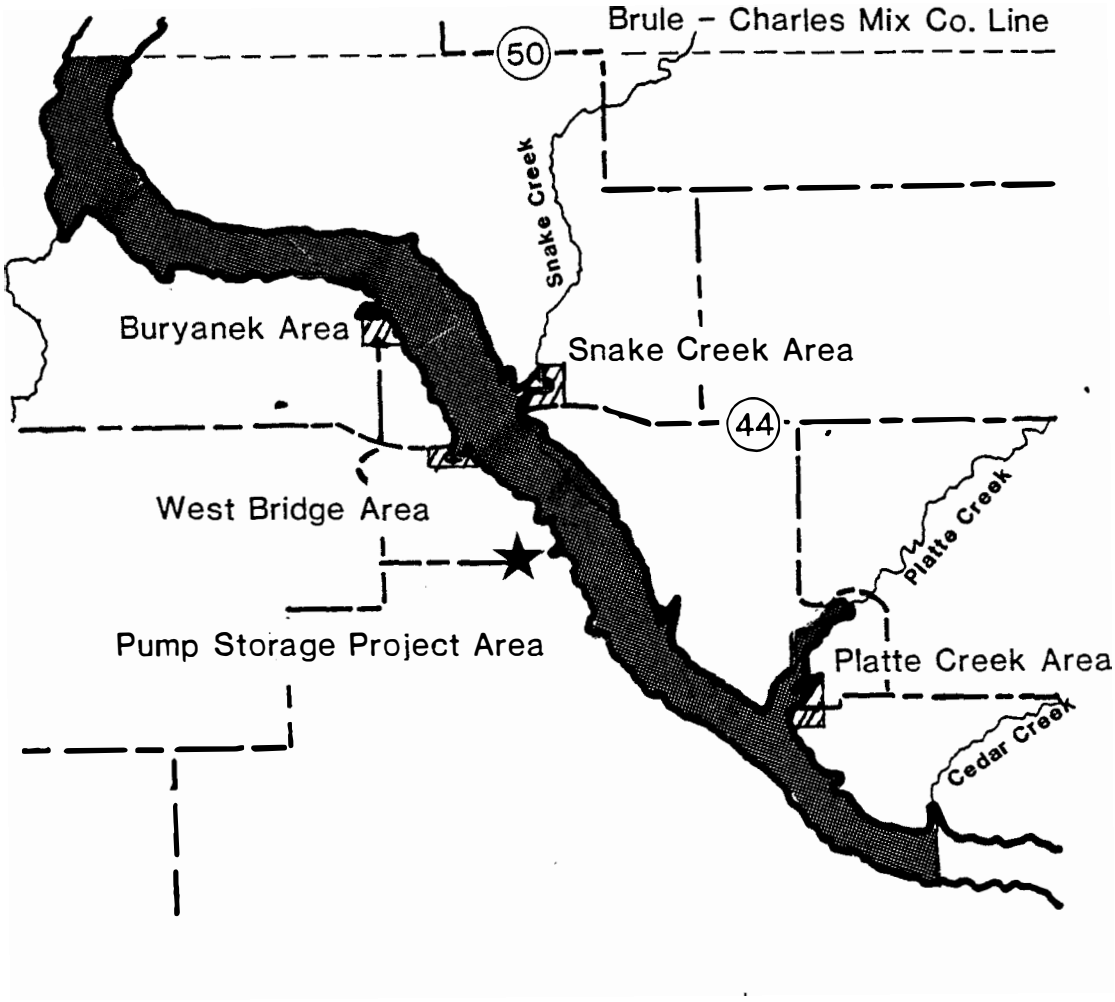

Figure 2. Detailed view of the Gregory County Pump Storage Project study area, Zone 2, 1981 and 1982.

Platte Creek recreation areas. There were several public areas in Zone 3, but because of the difficulty in reaching these smaller less developed areas they were infrequently used by anglers. There was a private boat ramp in Zone 3 adjacent to the North Point area. This ramp was not included in this survey but did harbor several boats and should be included in the sampling schedule of any future angler surveys on Lake Francis Case. The following areas were used in the survey of Zone 3: North Wheeler, Pease Creek, North Point, South Shore, and Whetstone Bay recreation areas.

METHODS

Sampling periods occured from May thru October 1981, and April thru October 1982. Schmidt (1975) indicated that winter fishing did not contribute substantially to the total yearly harvest; this period was excluded from the sampling schedule for this study. In 1981, the survey was conducted only in Zone 2 (Gregory County Pump Storage Project area). In 1982, the survey was expanded to include Zones 1 and 3. Comparisons between the 1981 and 1982 creel surveys are limited to Zone 2 for the months of May through September.

The Lake Francis Case creel survey was patterned after a study conducted on Lake Sharpe, South Dakota, which consisted of two independent surveys (Schmidt 1975). Aerial angler counts were used to estimate fishing pressure and angler interviews were used to estimate catch rate, mean party size, and mean angler day length. The results of the two surveys were used to estimate harvest.

Aerial Angler Count

The aerial angler count was stratified according to four criteria which may affect fishing pressure and harvest. The strata were month, type of day (weekend-holiday or weekday), type of fishing (boat or shore), and zone.

The number of flights was divided between weekend-holidays and weekdays (Table 1). Four flights per month were considered to be the minimum number needed for statistical interpretation (Schmidt 1975).

Table 1. Number of counting flights scheduled each month on Lake Francis Case, South Dakota, for the 1981 and 1982 survey periods.

	1981			1982		
Month	Weekday	Weekend-holiday	Total	Weekday	Weekend-holiday	Total
April	-	-	-	2	3	5
May	4	6	10	2	3	5
June	6	6	12	3	4	7
July	9	4	13	4	2	6
August	6	5	11	2	3	5
September	3	3	6	3	3	6
October	2	3	5	1	3	4
Total	30	27	57	17	21	38

The day was divided into one-hour intervals for the 1981 sampling period and was increased to two-hour intervals in 1982 when the entire reservoir was sampled. The length of the intervals corresponded to the approximate average length of inflight counting time. The starting time of each flight was selected randomly from these intervals. All estimates were for daylight hours; night fishing was not surveyed. Length of a day was considered to be one-half hour before sunrise to one-half hour after sunset.

Counts were made from a low flying airplane. A high-wing airplane with tandem seating offered the best visibility and facilitated counting, but the type of aircraft used for any particular flight varied with availability. A flight path which followed the middle of the reservoir permitted anglers to be counted on both sides except in the wider stretches of the reservoir where a zig-zag pattern was used.

In 1981, for each individual angling party observed, the number in the party, specific area of the contact, and angler activity were recorded on a data form (Fig. 3). This recording method was inefficient and made data coding and analysis difficult. In 1982, a five-key Clay Adams laboratory counter was used to tally counts. One key was designated for each of the following: number of active fishing boats, number of fishing boats not actively fishing (identified as occupied fishing boats but in transit or fishing line not in the water when surveyed), total number of boat anglers (both active and non-active fishing boats), total number of shore anglers, and the number of non-fishing recreational boats (water skiing, sailing, and canoes). The

page ____ of ____

Date _____ Day of Week _____ Air Service _____

Start _____ Stop _____ Weather _____

	FISHING TYPE (S-shore B-boat)	NO. IN PARTY	AREA (See map)	ACTIVITY (F-fishing B-beached T-trans. O-other U-unidentified)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Figure 3. Aerial angler count data form used in 1981 on the Lake Francis Case angler harvest survey.

counter was set to zero after the count for each zone was made. The counts were then transferred to a data sheet (Fig. 4). The mean number of anglers per fishing boat was calculated as the number of boat anglers (both active and non-active) divided by the total number of fishing boats. This calculation was done so that estimates could be made for the total number of active boat fishermen.

Angler Interview Survey

The angler interview survey was designed primarily to obtain catch rate information, but the following data were also collected: angler residence, party size, length of fishing day, and angler travel distance to fishing point. The strata used in the angler interview survey were the same as for the aerial count except for type of day. Schmidt (1975) found no consistent difference between catch rates for weekend-holidays and weekdays for any given month. Therefore, in order to avoid wasted sampling effort, emphasis was placed on sampling days of high angler visitation (i.e. weekends); a minimum of five angler interview days was scheduled each week during those periods. More than one angler interview day could be conducted on any given day since numerous creel clerks were available.

Angler interviews were conducted from mid-morning until dark on each angler interview day. The access area where interviews were to take place on any given day was chosen randomly. To avoid wasted sampling effort areas of high angler use were weighed more heavily than areas of low use when sampling schedules were set. Areas were weighed,

Date_____ Day_____ Weather_____

Start_____ Stop_____ _____

Zone	# of fishing boats	# of boat fishermen	# of shore fishermen	# of transit fishing boats	total

Figure 4. Recommended aerial angler count data form used in 1982 on the Lake Francis Case angler harvest survey.

in accordance with car counter information and observational information from aerial flights. If fishing pressure was low and no anglers were present at an assigned interview site by mid-afternoon, creel clerks were instructed to move to another location or terminate that sample day; this usually occurred on days of marginal fishing weather. Anglers were contacted at the end of a fishing day when possible. However, interviews were taken whenever an angling party was contacted. The interview was then updated at subsequent contacts.

Interview data were recorded on a data form (Fig. 5). The time of each interview, number of people in the party, and whether or not they had completed their fishing trip were recorded for each party interviewed. Anglers were asked what time they started fishing, what time they stopped, and how much time had been spent in activities other than fishing. This information was used to determine the length of actual fishing time for the party interviewed. Number and species of fish harvested were also recorded. In 1982 boat anglers were also asked what depth they fished at that day. This information was not included in the results of this study. Because low numbers of species other than walleyes (Stizostedion vitreum vitreum) were observed by creel clerks and walleye was the major species of interest, weights to the nearest gram were recorded for walleye only. The date, day of the week, access point, starting and ending time of that survey day, and weather conditions were recorded on each interview sheet.

page_____of_____

Date_____ Day of Week_____ Location_____

Start_____ Stop_____ Weather_____

Time									
Boat/Shore									
Completed?									
No. in Pty.									
Time Start									
Time Stop									
Hrs. Not Fish.									
Residence									
Depth Fished									
N. Pike - No.									
Wt.									
Walleye - No.									
- Wt.									
Sauger - No.									
- Wt.									
Crappie - No.									
- Wt.									
Ch.Cat. - No.									
- Wt.									
Whitebass-No.									
- Wt.									
Other - No.									
- Wt.									
Other - No.									
- Wt.									

Figure 5. Angler interview form used on the Lake Francis Case angler harvest survey.

DATA ANALYSIS

A Fortran IV computer program (Schmidt 1975) was used to calculate the desired statistics. The program calculated fishing pressure, mean catch rate, harvest of fish by species, mean trip length, mean party size, the associated standard error terms, the proportion of species in the total catch, and the travel distances of the anglers.

The total fishing effort and associated standard error squared were calculated individually in each month, zone, type of fishing, and type of day stratum using the following formula (Schmidt 1975; Cochran 1977):

$$P = ((\Sigma C_i)/n)\ (\bar{H})\cdot(D)$$

$$S_c^2 = \frac{1}{n(n-1)}\left(\Sigma C_i^2 - \frac{(\Sigma C_i)^2}{n}\right)\ (\bar{H}D)^2$$

where

P = fishing pressure in man-hours for the entire stratum,

C_i = fisherman count on the ith flight in the stratum,

n = number of flights in the stratum,

$\bar{H}$ = mean number of daylight hours in a day,

D = number of days in the stratum, and

S_c^2 = standard error square of the mean fisherman count, expanded to the entire stratum.

The estimates were summed over the type of day strata to obtain monthly estimates for each zone and type of fishing. Monthly totals were summed over all months to obtain yearly estimates.

The catch rate for each species of fish was calculated as recommended by Schmidt (1975):

$$\overline{CR} = \frac{(\Sigma F_i)/n}{(\Sigma H_i)/n} = \frac{\Sigma F_i}{\Sigma H_i}$$

where

$\overline{CR}$ = mean catch rate in fish per fisherman-hour,

H_i = number of fisherman-hours expended by the ith party,

F_i = number of fish caught by the ith party, and

n = number of parties interviewed.

The catch rate is the mean number of fish caught divided by the mean number of angler-hours expended for all parties interviewed in the particular stratum. Since these are both calculated statistics, the formula for the variance of the division of two statistics must be used (Schmidt 1975):

$$S^2_{\overline{CR}} = \overline{CR}^2 \left(\frac{S^2_{\bar{F}}}{\bar{F}^2} + \frac{S^2_{\bar{H}}}{\bar{H}^2} - \frac{2\ Cov\ (FxH)}{(\bar{F})(\bar{H})}\right)$$

where

$S^2_{\overline{CR}}$ = standard error square of the mean catch rate,

$S^2_{\bar{F}} = \frac{1}{n(n-1)} \left(\Sigma F_i^2 - \frac{(\Sigma F_i)^2}{n}\right)$, standard error square of mean number of fish, and

$S^2_{\bar{H}} = \frac{1}{n(n-1)} \left(\Sigma H_i^2 - \frac{(\Sigma H_i)^2}{n}\right)$, standard error square of mean hours.

$$\text{Cov (FxH)} = \frac{1}{n(n-1)}\left(\Sigma F_i H_i - \frac{(\Sigma F_i)(\Sigma H_i)}{n}\right), \text{ covariance of fish and hours}$$

$\bar{F}$ = mean number of fish per party,

$\bar{H}$ = mean number of man-hours per party, and

n = number of parties interviewed.

The catch rates and standard error square terms were calculated for each species and all species combined within each month, zone, and type of fishing. Catch rates were not averaged over strata to obtain overall catch rates. Overall catch rates were calculated by summing the harvest estimates and pressure estimates and then dividing to determine the overall mean catch rates.

Estimates of the number of fish harvested were calculated as the product of the mean catch rate and the total estimated fishing pressure for the month. Total monthly harvest was determined by adding the estimates for the weekend-holiday and weekday strata. Harvest was calculated for each species within each month, zone, and type of fishing. Seasonal totals were calculated by adding the harvest estimates and the associated standard error square terms over all months. Angler harvest was calculated by using the following formula (Schmidt 1975):

$$Y = (P)(\overline{CR})$$

$$S_Y^2 = (S_p^2)(\overline{CR}^2) + (S_{\overline{CR}}^2)(P_P^2)$$

where

Y = harvest in numbers for a particular species,

P = estimated fishing pressure,

$\overline{CR}$ = mean catch rate for a particular species,

S_Y^2 = standard error square of the estimated harvest, assuming no correlation between fishing pressure and mean catch rate,

S_P^2 = standard error square of the estimated fishing pressure, and

$S_{\overline{CR}}^2$ = standard error square of the mean catch rate.

An analysis of variance was computed for the aerial count data with the SAS computer procedure GLM (Helwig and Council 1979); this was done to test if stratification according to the design criteria was necessary. A factorial analysis of the completely random design with months, type of fishing, and type of day as the main effects was used. The Waller-Duncan k-ratio t-test was used to test the main effects used in the analysis of variance. All pairwise tests were performed using Student's t-test (Steel and Torrie 1980). All statistical tests were calculated using the 95% probability level.

RESULTS AND DISCUSSION

Fishing Pressure

The estimated total fishing pressure in 1981 for Zone 2, May through October, was 188,631 angler-hours (Table 2). This constituted an average of 19.5 angler-hours per hectare for the sample period (7.9 angler-hours per acre). The greatest fishing pressure, 76.9% of the total, occurred during the months May and June (Table 2). Fishing pressure then decreased for July and remained low through August and September until October when it declined to the lowest value for the sample period (Table 2).

The monthly distributions of boat and shore fishing pressure were similar throughout the period. Shore fishing never contributed more than 9.0% to the monthly estimates and only 7.2% to the total fishing pressure (Table 2).

An analysis of variance with month, type of fishing, and type of day as the main effects showed significant differences for two of the main effects, indicating the need for stratification according to month and type of fishing (Appendix Table 1). Type of day was not significant. Calculation of least square means indicated that a significant month times type of fishing interaction resulted from unusally high counts in May and June for boat anglers (Appendix Table 2).

The total estimated fishing pressure for 1982 (zones and types of fishing combined) was 557,576 angler-hours (Table 3) or an

Table 2. Estimated total fishing pressure (angler-hours), by month and type of fishing, and total and percent of total fishing pressure by month, Lake Francis Case, South Dakota, May through October 1981.

	Angler-hours of fishing			
	Boat	Shore	Total	% total
May	64,305	5,660	69,965	37.1
June	70,763	4,410	75,173	39.8
July	11,357	974	12,331	6.5
August	13,786	911	14,697	7.8
September	13,500	1,330	14,830	7.9
October	1,403	232	1,635	0.9
Total	175,114	13,517	188,631	
% total	92.8	7.2		100.0

Table 3. Estimated total fishing pressure (angler-hours), and percent of total fishing pressure, by month and type of fishing, zones combined, Lake Francis Case, South Dakota, April through October 1982.

	Angler-hours of fishing			
	Boat	Shore	Total	% total
April	24,290	5,901	30,191	5.4
May	141,238	13,881	155,119	27.8
June	193,633	16,546	210,179	37.7
July	99,518	7,044	106,562	19.1
August	26,347	6,553	32,900	5.9
September	17,820	2,671	20,491	3.7
October	1,772	362	2,134	0.4
Total	504,618	52,958	557,576	
% total	90.5	9.5		100.0

average of 12.9 angler-hours per hectare (5.2 angler-hours per acre). Zone 1 received 49.4% of the pressure (Table 4), this constituted 275,393 total angler-hours and 14.7 angler-hours per hectare (5.9 angler-hours per acre) of the fishing pressure. The Gregory County Pump Storage Project area, Zone 2, received 21.8% of the pressure, this constituted 121,303 total angler-hours and 11.2 angler-hours per hectare (4.5 angler-hours per acre) of the fishing pressure. Zone 3 received 28.8% of the pressure; this was 160,880 angler-hours and 12.1 angler-hours per hectare (4.9 angler-hours per acre) of the fishing pressure. Nearly all (90.5%) of the total estimated fishing pressure was expended by boat anglers (504,618 angler-hours), while only 9.5% (52,958 angler-hours) was accounted for by shore angling.

Low fishing pressure occurred in the month of April (zones and type of fishing combined). Fishing pressure then increased in May (Table 3). The highest fishing pressure occurred in June. Zone 2 and 3 peaks were in the month of June, but Zone 1 peaked in May (Table 5). Fishing pressure declined in July to a value half that of the June peak. Fishing pressure continued to decline in August and September and reached a low of 2,134 angler-hours in October. In general, fishing pressure was light in early spring, peaked in late spring-early summer, then declined to the lowest estimated value in the fall.

An analysis of variance using a factorial analysis of the completely random design with month, zone, type of fishing, and type of day as the main effects, indicated that significant differences occurred (Appendix, Table 3). As in 1981 the analysis of variance confirmed the

Table 4. Estimated total fishing pressure (angler-hours), months combined, by type of fishing and zone, and total and percent of total fishing pressure by zone, Lake Francis Case, South Dakota, April through October 1982.

Zone	Boat	Shore	Total	% total
1	244,338	31,055	275,393	49.4
2	110,920	10,383	121,303	21.8
3	149,360	11,520	160,880	28.8

Table 5. Estimated total fishing pressure (angler-hours), types of fishing combined, by zone and month, Lake Francis Case, South Dakota, April through October 1982.

	Zone 1	Zone 2	Zone 3	Total
April	25,019	3,219	1,955	30,193
May	105,375	29,386	20,357	155,118
June	90,202	48,362	71,614	210,278
July	28,302	28,890	49,370	106,562
August	15,143	7,846	9,911	32,900
September	10,144	3,278	7,069	20,491
October	1,208	322	604	2,134
Total	275,393	121,303	160,880	557,576

need for stratification according to month and type of fishing. In addition, type of day and zone were found to have a significant effect on fishing pressure.

Four of the 10 possible interactions were significant. Comparison of least square means indicated that these interactions may have been the result of high boat angler counts for weekend-holiday days during July (Appendix Table 4). Only two weekend-holiday days were sampled during July, a month of high angler visitation. Fishing pressure was observed to be sporadic during July causing a high variability among the counts. An increase in the number of weekend-holiday days sampled could have reduced the variability and improved the accuracy of the estimate.

Comparison of the total Zone 2 boat angling pressure for 1981 and 1982 (May through September), indicated that significantly higher fishing pressure occurred in 1981 (Table 6). Comparisons of fishing pressure by month showed a similar trend. In both cases heavy pressure occurred in May, peaked in June, and decreased in July through October. In all months except July the fishing pressure estimates were highest in 1981.

When fishing pressure estimates of this study are compared with past years for Lake Francis Case (Table 7) it can be seen that as the reservoir matured an increase in angler pressure per hectare occurred. In 1955, three years after closure of the Fort Randall Dam, fishing pressure was only 4.2 angler-hours per hectare (Schields 1956). By 1960 fishing pressure had increased to 11.7 angler-hours per hectare

Table 6. Estimated Zone 2 total fishing pressure (angler-hours), types of fishing combined, by month and year, Lake Francis Case, South Dakota, May through October 1981 and 1982.

	1981	1982
May	69,965	29,386
June	75,173	48,362
July	12,331	28,890
August	14,697	7,846
September	14,830	3,278
October	1,635	322
Total	188,631	118,084

Table 7. Comparison of fishing pressure estimates from 1981 and 1982 for Lake Francis Case, South Dakota, with estimates of fishing pressure from other creel surveys.

	Fishing pressure (angler-hours/ hectare)	Type of fishery (major spp. in creel)	Classification	Size (hectares)
Lake Francis Case, South Dakota				
1955 (Schields 1956)	4.2	2,3,1	cwr[a]	28,500
1956 (Schields 1957)	5.6	3,6	cwr	28,000
1960 (Nelson 1961)	11.7	4,7	cwr	37,000
1981 (Present study) (Zone 2)	17.8	8	cwr	10,600
1982 (Present study) (Zone 2)	11.4	8	cwr	10,600
1982 (Present study) (all zones combined)	13.6	8	cwr	41,000
Lake Sharpe, South Dakota				
1974 (Schmidt 1975)	10.9	8	cwr	22,300
Grenda Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	11.5	5,1,2	wwr[b]	25,900
Sardis Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	9.9	4	wwr	23,700
Enid Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	10.8	4	wwr	11,300
Folsom Lake, California				
1960 (von Geldern 1972)	70.7	2,1	wwr	4,200
Clear Lake, Missouri				
average 1949 - 52 (Kathrein 1953)	21.4	5,2	wwr	670
Spirit Lake, Iowa				
average 1953 - 55 (Rose 1956)	32.0	3,6,8	cwl[c]	2,300

Table 7. (Continued)

	Fishing pressure (angler-hours/ hectare)	Type of fishery (major spp. in creel)	Classification	Size (hectares)
East Okoboji Lake, Iowa average 1953 - 55 (Rose 1956)	95.4	3,6	cwl	570
West Okoboji Lake, Iowa average 1953 - 55 (Rose 1956)	28.4	6,3,8	cwl	1,600
10 small Oklahoma lakes 1965 (Brown 1969)	341.0 - 1,537.0	1,4	wwl[d]	50 - 500

1 - blackbass (Micropterus spp.), 2 - bluegill (Lepomis macrochirus), 3 - bullhead (Ictalurus spp.), 4 - catfish (Ictalurus spp.), 5 - crappie (Pomoxis spp.), 6 - yellow perch (Perca flavescens), 7 - sauger (Stizostedion canadense), 8 - walleye (Stizostedion vitreum vitreum).

a - coolwater reservoir, b - warmwater reservoir, c - coolwater natural lake, d - warmwater natural lake.

(Nelson 1961). In 1963, completion of the Big Bend Dam defined the upstream boundary of Lake Francis Case and created a tail race fishery in the reservoir. This tail race area added a new point of access to the reservoir and added a new dimension to the fishery. Estimates of 1981 Zone 2 fishing pressure were the highest observed for Lake Francis Case and are believed to be the result of good angler success in 1981. The 1982 estimates were lower than those of 1981 and were believed to be due to poor angler success in 1982 relative to 1981.

Changes in fishing pressure through the years may have been affected by changes in the species composition of the creel. In 1955, when fishing pressure was low, the major species comprising the creel were bluegills (Lepomis macrochirus), bullheads (Ictalurus spp.)., and blackbass (Micropterus spp.). Neither bluegills nor blackbass were found in the creel during the present study. The major species comprising the 1956 creel were bullheads and yellow perch (Perca flavescens) and in 1960 the major species in the creel were crappies (Pomoxis spp.) and saugers (Stizostedion canadense) (Schields 1956, 1957; Nelson 1961). In 1981 and 1982 the major species in the creel was walleye. Changes in species composition of the creel from 1955 to 1981 and 1982 were accompanied by successive increases in fishing pressure. This indicated that anglers may have preferred walleyes over bluegills or other species. Other factors such as increased leisure time, increased notoriety of the reservoir, and optimum angler success may also be attributed to the increased fishing pressure on Lake Francis Case since 1955. The addition of the tail race area in 1963 provided

more access to the reservoir and could also be responsible for increased fishing pressure.

Estimates of fishing pressure obtained in this study were higher than those obtained for other large reservoirs (Table 7). During 1974 on Lake Sharpe, South Dakota, fishing pressure was 10.9 angler-hours per hectare (Schmidt 1975). In 1982 on Lake Francis Case estimated fishing pressure was 13.6 angler-hours per hectare. Average estimates of fishing pressure for large flood control reservoirs in California ranged from 9.9 - 11.5 angler-hours per hectare (Barkley 1960). Fishing pressure for small reservoirs, ranged from 21.4 to 70.7 angler-hours per hectare (Kathrein 1953; von Geldern 1972), and were higher than the estimates of Lake Francis Case (Table 7). The fishing pressures obtained for small natural lakes were higher than those obtained during this study and ranged from 28.4 - 1,537.0 angler-hours per hectare (Table 7) (Rose 1956; Brown 1969). This observation is to be expected, because of the extensiveness of Lake Francis Case.

Catch Rates

Average catch rate for boat and shore anglers in 1981 (May through September) was 0.31 fish per angler-hour (Table 8). Boat anglers had a higher catch rate (0.31 fish per angler-hour) than shore anglers (0.26 fish per angler-hour).

Catch rates for boat anglers (all species combined) ranged from a high of 0.37 fish per angler-hour in September to a low of 0.28 in June (Table 8). Boat fishing catch rates for walleyes were high in

Table 8. Estimated average monthly and seasonal catch rates (fish per angler-hour) for all species combined, by type of fishing, Lake Francis Case, South Dakota, May through September 1981.

	Boat	Shore	Combined
May	0.34	0.26	0.33
June	0.28	0.33	0.28
July	0.34	0.45	0.35
August	0.32	0.09	0.31
September	0.37	-	0.37
Seasonal	0.31	0.26	0.31

May, declined to a low in July and then increased to a seasonal peak in September (Fig. 6). During months of low walleye catch rates, higher catch rates for species other than walleye maintained the overall catch rate within a narrow range throughout the sampling period. No data on catch rates were collected in the month of October because low fishing pressure resulted in no angler contacts.

Catch rates for shore anglers ranged from a high of 0.45 fish per angler-hour in July to a low of 0.09 fish per angler-hour in August (Table 8). Unlike boat anglers, shore angler catch rates were highest for species other than walleye (Fig. 6). Catch rates for boat anglers were higher than those for shore anglers for all months except June and July.

Catch rate in 1982 for all zones and types of fishing combined was 0.27 fish per angler-hour (Table 9). Boat anglers had the highest catch rate for the period with 0.27 fish per angler-hour; shore anglers caught 0.11 fish per angler-hour.

The highest seasonal average catch rates were obtained by boat anglers in all zones (Table 9). The highest seasonal average boat (0.32 fish per angler-hour) and shore angler (0.28 fish per angler-hour) catch rate occurred in Zone 1. The lowest seasonal average boat fishing catch rate (< 0.01 fish per angler-hour) occurred in Zone 3. No estimate of shore fishing catch rate was calculated for Zone 2 because of insufficient data.

Monthly boat fishing catch rates in 1982 (all species and zones combined) ranged from 0.39 fish per angler-hour in July to 0.06 in

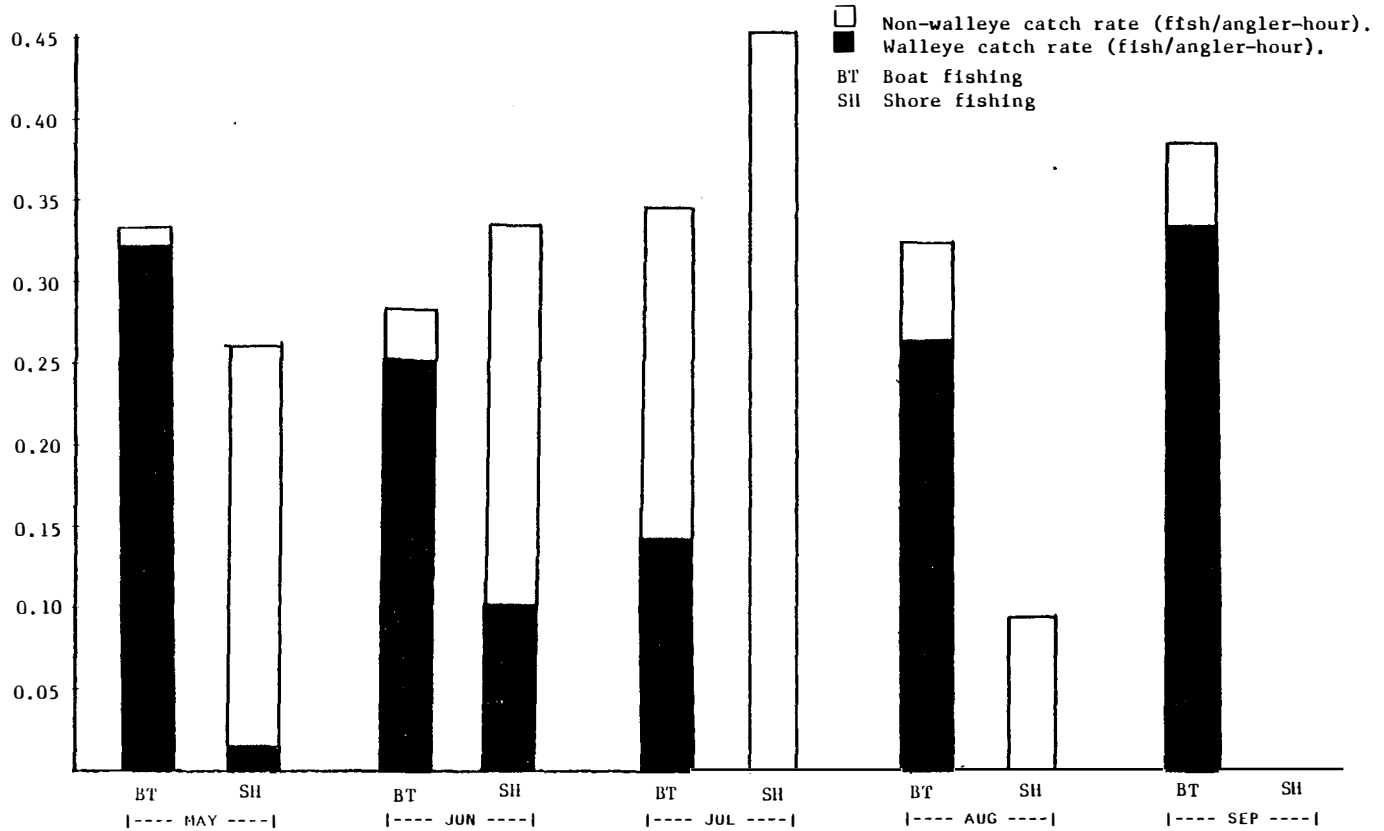

Figure 6. Estimated total average monthly catch rates, by walleye (Stizostedion vitreum vitreum) and non-walleye species, for boat and shore types of fishing, Lake Francis Case, South Dakota, Zone 2, May through September 1981.

Table 9. Estimated average monthly and seasonal catch rates (fish per angler-hour) for all species combined, by zones, zones combined, and type of fishing, Lake Francis Case, South Dakota, April through October 1982.

	Zone 1		Zone 2		Zone 3		Zones combined	
	Boat	Shore	Boat	Shore	Boat	Shore	Boat	Shore
April	0.15	-	-	-	-	-	0.14	-
May	0.28	-	0.31	-	0.27	0.14	0.29	0.13
June	0.39	0.41	0.29	-	0.15	0.00	0.31	0.24
July	0.49	0.17	0.36	-	0.19	0.35	0.39	0.17
August	0.15	0.15	0.00	-	0.14	-	0.14	0.15
September	0.16	-	0.15	-	-	-	0.16	-
October	0.06	0.13	-	-	-	-	0.06	0.13
Seasonal	0.32	0.28	0.29	-	0.18	0.05	0.27	0.11

October (Table 9). Boat fishing catch rate for walleyes was highest in the month of May, declined in June and July, and continued to decline to the seasonal low of 0.02 walleyes per angler-hour in October (Fig. 7).

Catch rates for shore anglers ranged from a high of 0.24 fish per angler-hour in June to a low of 0.13 in May and October (Table 9). Due to insufficient data there were no estimates of shore fishing catch rates for April and September. Catch rates for walleyes by shore anglers were highest in June and lowest in August (Fig. 7). Boat fishing catch rates for walleyes were higher than shore fishing catch rates in all months except October. This higher shore angler catch rate was caused by good fishing success in the Big Bend Dam tail race of Zone 1 where increased flows caused by the fall drawdown may have caused fish concentration in that area. Insufficient numbers of shore angler interviews in 1982 for Zone 2 resulted in estimates being made for boat fishing only.

Monthly boat fishing catch rates in Zone 2 for the 1981 and 1982 periods indicated that for the months of May through July catch rates were not significantly different for month by month comparisons (Fig. 8). In addition, the walleye catch rates were not significantly different. No valid comparisons could be made for August and September because of the small sample size obtained in 1982. It did appear, however, that the 1981 catch rates were higher than those of 1982 for September.

Walleye catch rates and boat fishing pressure estimates followed similar patterns in both 1981 and 1982 (Fig. 9 and 10). This

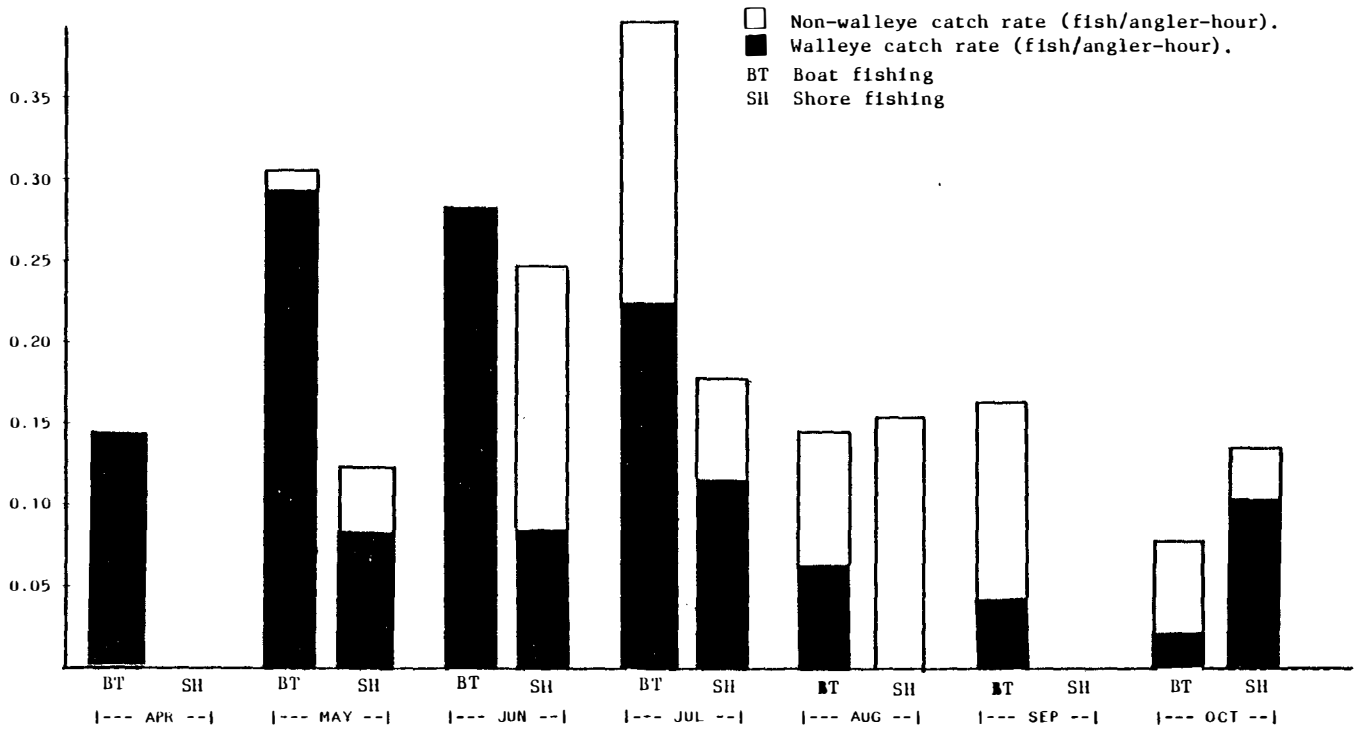

Figure 7. Estimated total average monthly catch rates, zones combined, by walleye (Stizostedion vitreum vitreum) and non-walleye species, for boat and shore types of fishing, Lake Francis Case, South Dakota, April through October 1982.

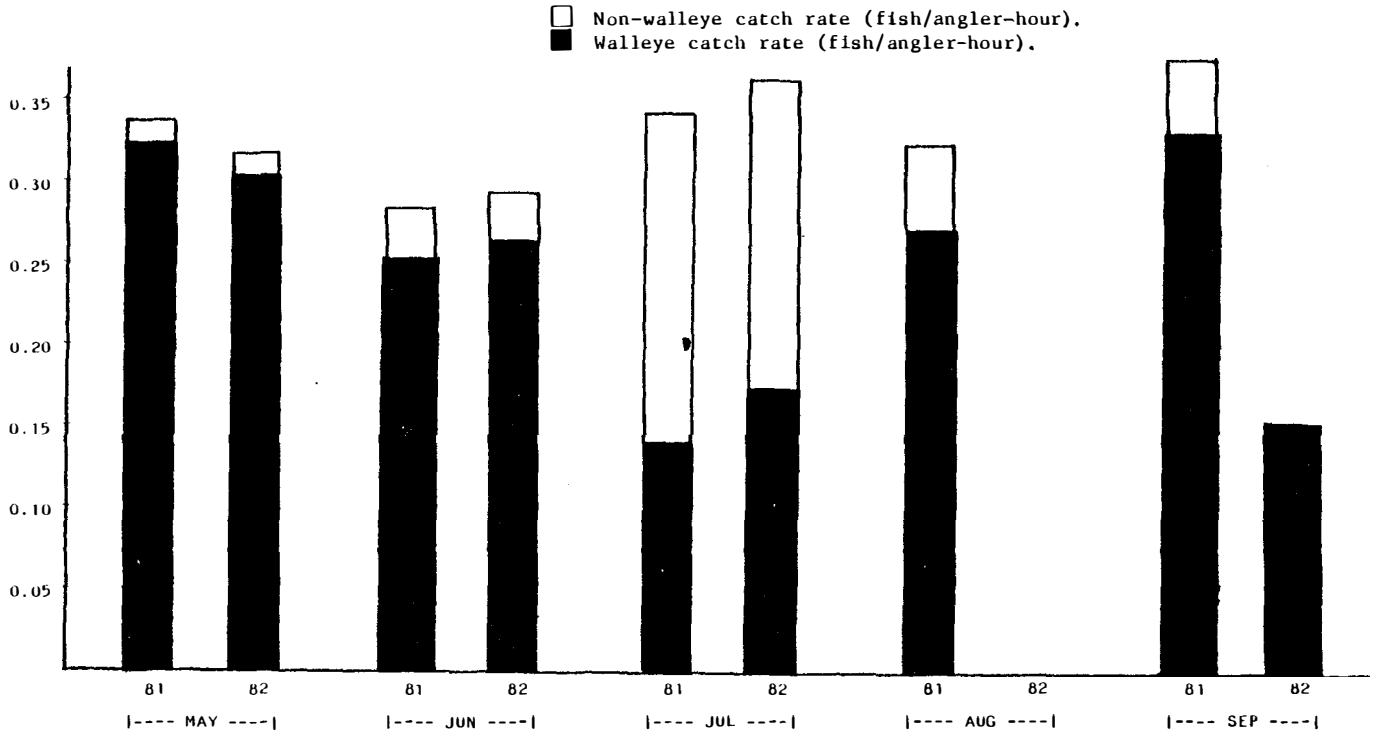

Figure 8. Estimated Zone 2 total average monthly boat angling catch rates by walleye (Stizostedion vitreum vitreum) and non-walleye species, Lake Francis Case, South Dakota, May through September 1981 and 1982.

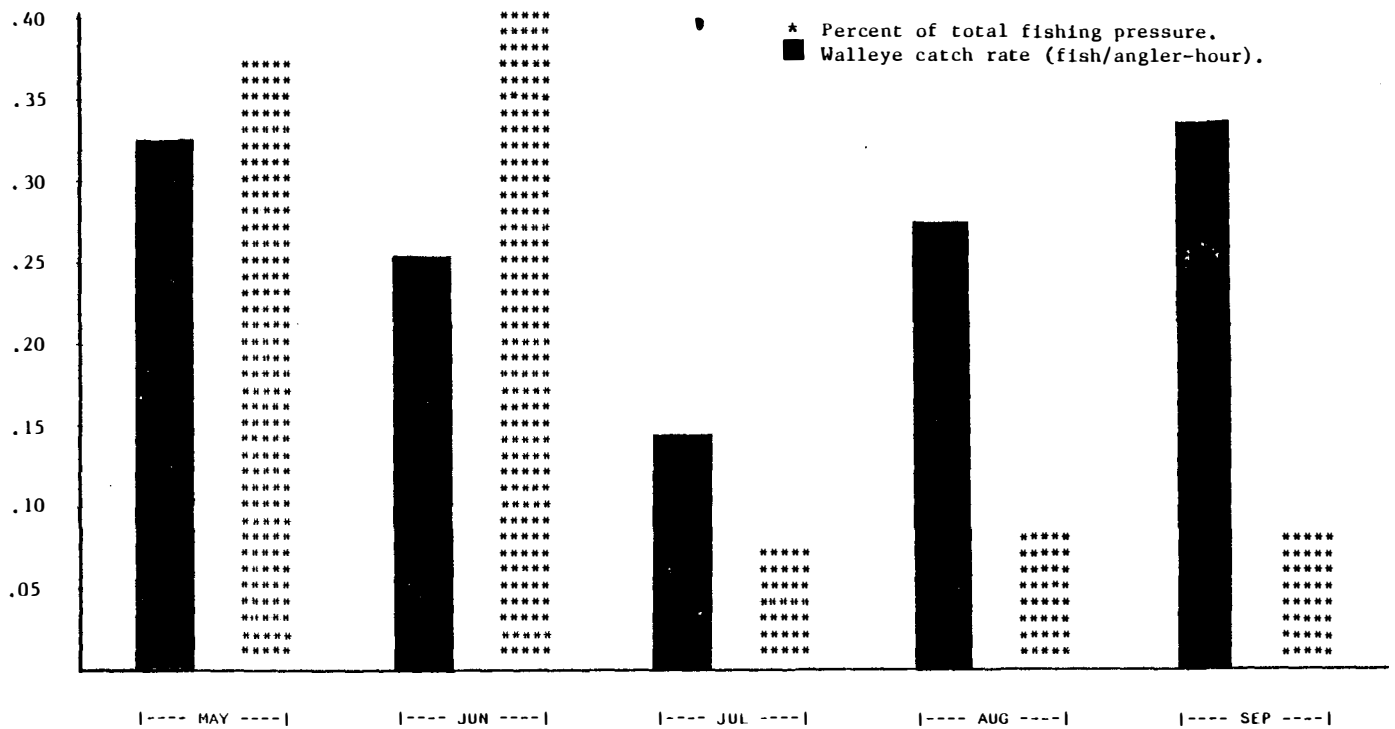

Figure 9. Percent of total estimated boat fishing pressure compared to average monthly walleye (Stizostedion vitreum vitreum) catch rate, Lake Francis Case, South Dakota, May through September 1981.

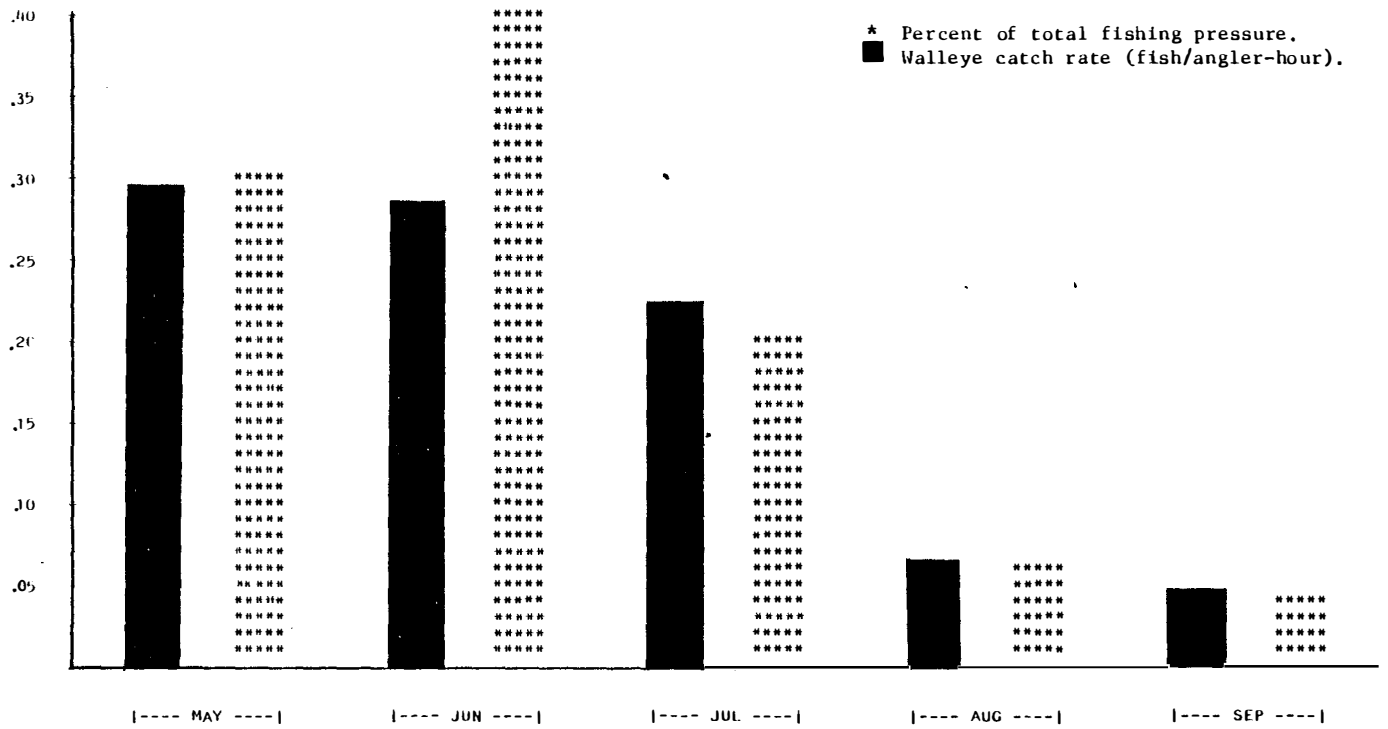

Figure 10. Percent total estimated boat fishing pressure compared to average monthly walleye (Stizostedion vitreum vitreum) catch rate, Lake Francis Case, South Dakota, May through September 1982.

was also observed by Schmidt (1975) on Lake Sharpe. Both walleye catch rate and boat fishing pressure estimates were high in May and June. A decrease in the estimated walleye catch rate was coincidental with a decrease in the fishing pressure for the month of July. A higher walleye catch rate in July 1982 was accompanied by a higher boat fishing pressure relative to the July 1981 estimates. Increases in the walleye catch rates for August and September of 1981 were likewise accompanied by increases in boat angler fishing pressure. This evidence suggests a possible relationship between walleye catch rates and the amount of boat angling pressure. A fuller investigation needs to be done to test this hypothesis.

Catch rate estimates from past creel surveys of Lake Francis Case were generally higher than those obtained for this study. In 1955, the catch rate was 0.88 fish per angler-hour (Table 10). Catch rate decreased in 1956 (0.56 fish per angler-hour) and declined further in 1960 (0.28 fish per angler-hour) (Schields 1956, 1957; Nelson 1961). Catch rates in this study were similar to those obtained for 1960 (Table 10). Changes in catch rates may be attributed to changing reservoir conditions and shifts in the species composition of the fish populations. As inundated shoreline vegetation decomposed, spawning sites of some fish species decreased. This could lead to reduced numbers or even elimination of these species and a consequent reduction in the number of fish available for angling. If these species were highly vulnerable to angling relative to other species in the fishery this would reduce angler success and catch rate.

Table 10. Comparison of catch rate estimates from 1981 and 1982 for Lake Francis Case, South Dakota, with estimates of catch rate from other creel surveys.

	Catch rate (fish/ angler-hour)	Type of fishery (major spp. in creel)	Classification	Size (hectares)
Lake Francis Case, South Dakota				
1955 (Schields 1956)	0.88	2,3,1	cwr[a]	28,500
1956 (Schields 1957)	0.56	3,6	cwr	28,000
1960 (Nelson 1961)	0.28	4,7	cwr	37,000
1981 (Present study) (Zone 2)	0.31	8	cwr	10,600
1982 (Present study) (Zone 2)	0.29	8	cwr	10,600
1982 (Present study) (all zones combined)	0.27	8	cwr	41,000
Lake Sharpe, South Dakota				
1974 (Schmidt 1975)	0.34	8	cwr	22,300
Grenda Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	1.18	5,1,2	wwr[b]	25,900
Sardis Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	0.90	4	wwr	23,700
Enid Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	0.89	4	wwr	11,300
Folsom Lake, California				
1960 (von Geldern 1972)	0.30	2,1	wwr	4,200
Clear Lake, Missouri				
average 1949 - 52 (Kathrein 1953)	0.48	5,2	wwr	670
Spirit Lake, Iowa				
average 1953 - 55 (Rose 1956)	1.17	3,6,8	cwl[c]	2,300

Table 10. (Continued)

	Catch rate (fish/ angler-hour)	Type of fishery (major spp. in creel)	Classification	Size (hectares)
East Okoboji Lake, Iowa average 1953 - 55 (Rose 1956)	1.44	3,6	cwl	570
West Okoboji Lake, Iowa average 1953 - 55 (Rose 1956)	1.18	6,3,8	cwl	1,600
10 small Oklahoma lakes 1965 (Brown 1969)	0.10 - 3.0	1,4	wwl[d]	50 - 500

1 - blackbass (Micropterus spp.), 2 - bluegill (Lepomis macrochirus), 3 - bullhead (Ictalurus spp.), 4 - catfish (Ictalurus spp.), 5 - crappie (Pomoxis spp.), 6 - yellow perch (Perca flavescens), 7 - sauger (Stizostedion canadense), 8 - walleye (Stizostedion vitreum vitreum).

a - coolwater reservoir, b - warmwater reservoir, c - coolwater natural lake, d - warmwater natural lake.

Comparison of the Lake Francis Case catch rates of this study with other large reservoirs indicated that Lake Francis Case catch rates were generally lower (Table 10). Different species composition in the creel coupled with differences in reservoir conditions, as mentioned above, may have affected catch rates and could account for the lower catch rates observed on Lake Francis Case.

When catch rate information from small natural lakes is compared with the results of this study it can be seen that the small lakes had higher catch rates (Table 10). Smaller lakes tend to be more productive per unit surface area and are usually fished more intensely; both conditions would increase catch rate.

Harvest Estimates

The total harvest of fish in 1981 from Zone 2 was 57,910 fish (Table 11), which was 5.5 fish per hectare (2.2 fish per acre). The total catch for the 1981 sampling period was comprised of 83.7% walleyes, 4.1% channel catfish (Ictalurus punctatus), and 3.2% carp (Cyprinus carpio). The remaining 9.0% in order of decreasing abundance was comprised of white bass (Morone chrysops), yellow perch, saugers, drums (Aplodinotus grunniens), goldeyes (Hiodon alosoides), northern pike (Esox lucius), and crappies. The highest monthly harvest (Table 12) was in May with an estimated 23,115 fish (40.0% of the total period harvest). The June harvest estimate was 20,978 fish (36.3%). Boat anglers accounted for 94.0% of the 1981 harvest (54,435 fish) (Table 13).

Table 11. Estimated harvest and percent of total harvest, by species, types of fishing combined, Lake Francis Case, South Dakota, May through September 1981, and April through October 1982.

Common name	Scientific name	1981 Zone 2 Number of fish	1981 Zone 2 % of total	1982 Zone 2 Number of fish	1982 Zone 2 % of total	1982 Zones combined Number of fish	1982 Zones combined % of total
Walleye	Stizostedion vitreum vitreum	48,451	83.7	24,815	78.6	110,687	81.2
Channel catfish	Ictalurus punctatus	2,366	4.1	2,402	7.6	13,044	9.6
Carp	Cyprinus carpio	1,863	3.2	0	0.0	225	0.2
White bass	Morone chrysops	1,626	2.8	3,829	12.1	7,827	5.8
Yellow perch	Perca flavescens	1,300	2.2	103	0.3	859	0.6
Sauger	Stizostedion canadense	800	1.4	264	0.8	2,265	1.7
Drum	Aplodinotus grunniens	718	1.2	83	0.3	673	0.5
Goldeye	Hiodon alosoides	641	1.1	0	0.0	280	0.2
Northern pike	Esox lucius	104	0.2	0	0.0	3	< 0.1
Crappie	Pomoxis spp.	41	< 0.1	49	0.2	49	< 0.1
Bullhead	Ictalurus spp.	0	0.0	10	< 0.1	238	0.2
Total		57,910	100.0	31,555	100.0	136,150	100.0

Table 12. Monthly harvest estimates, all species and types of fishing combined, by month and zone, Lake Francis Case, South Dakota, May through September 1981, and April through October 1982.

	April	May	June	July	August	September	October	Total
1981								
Zone 2	-	23,115	20,978	4,346	4,433	5,038	-	57,910
1982								
Zone 1	2,972	26,278	34,206	11,848	2,214	1,383	46	78,947
Zone 2	-	8,227	12,951	9,915	-	462	-	31,555
Zone 3	-	5,375	9,598	9,527	1,148	-	-	25,648
Zones combined	2,972	39,880	56,755	31,290	3,362	1,845	46	136,150

Table 13. Estimated harvest and percent of total harvest, by type of fishing, Lake Francis Case, South Dakota, Zone 2, May through September 1981, and April through October 1982, for the entire reservoir.

	Boat		Shore	
	Number of fish	% of total	Number of fish	% of total
1981	54,435	94.0	3,475	6.0
1982	130,522	95.9	5,628	4.1

The total estimated harvest for the 1982 period was 136,150 fish or the equivalent of 3.3 fish per hectare (1.3 fish per acre) for the months of May through October (Table 12). Walleyes accounted for 81.2% of the total harvest, channel catfish 9.6%, white bass 5.8%, and the remaining 3.4% was made up of saugers, yellow perch, drums, goldeyes, bullheads, carp, crappies, and northern pike in order of decreasing abundance (Table 11).

In 1982 for Zone 1 an estimated 78,947 fish were harvested (Table 12) representing 58.0% of the total harvest or 4.6 fish per hectare (1.9 fish per acre). The Zone 3 estimate was 25,648 fish or 2.0 fish per hectare (0.8 fish per acre).

The 1982 boat angling harvest for Zone 2 was 31,555 fish or 3.4 fish per hectare (1.4 fish per acre). Walleyes accounted for 78.6% of the total boat harvest, white bass 12.1%, channel catfish 7.6%, and the remaining 1.7% was comprised of saugers, yellow perch, drums, crappies, and bullheads in order of decreasing abundance. The greatest monthly harvest in Zone 2 for the 1982 period was in June (36.3% of the total boat harvest).

Harvest estimates from this study were consistent with those for past Lake Francis Case studies except during 1981 (Zone 2) when 5.5 fish per hectare were harvested (Table 14). This high harvest rate in 1981 may be attributed to both a higher fishing rate and a higher catch rate.

Harvest rates for Lake Sharpe, South Dakota, (Schmidt 1975) were similar to those obtained for Lake Francis Case except for 1981

Table 14. Comparison of harvest rate estimates from 1981 and 1982 for Lake Francis Case, South Dakota, with estimates of harvest rate from other creel surveys.

	Harvest rate (fish/ hectare)	Type of fishery (major spp. in creel)	Classification	Size (hectares)
Lake Francis Case, South Dakota				
1955 (Schields 1956)	3.7	2,3,1	cwr[a]	28,500
1956 (Schields 1957)	3.2	3,6	cwr	28,000
1960 (Nelson 1961)	3.1	4,7	cwr	37,000
1981 (Present study) (Zone 2)	5.5	8	cwr	10,600
1982 (Present study) (Zone 2)	3.0	8	cwr	10,600
1982 (Present study) (all zones combined)	3.3	8	cwr	41,000
Lake Sharpe, South Dakota				
1974 (Schmidt 1975)	3.7	8	cwr	22,300
Grenda Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	13.6	5,1,2	wwr[b]	25,900
Sardis Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	8.9	4	wwr	23,700
Enid Lake, Mississippi				
average 1953 - 55 (Barkley 1960)	9.6	4	wwr	11,300
Folsom Lake, California				
1960 (von Geldern 1972)	21.0	2,1	wwr	4,200
Clear Lake, Missouri				
average 1949 - 52 (Kathrein 1953)	10.3	5,2	wwr	670
Spirit Lake, Iowa				
average 1953 - 55 (Rose 1956)	37.3	3,6,8	cwl[c]	2,300

Table 14. (Continued)

	Harvest rate (fish/ hectare)	Type of fishery (major spp. in creel)	Classification	Size (hectares)
East Okoboji Lake, Iowa average 1953 - 55 (Rose 1956)	66.4	3,6	cwl	570
West Okoboji Lake, Iowa average 1953 - 55 (Rose 1956)	33.5	6,3,8	cwl	1,600
10 small Oklahoma lakes 1965 (Brown 1969)	168.0 - 598.0	1,4	wwl[d]	50 - 500

1 - blackbass (Micropterus spp.), 2 - bluegill (Lepomis macrochirus), 3 - bullhead (Ictalurus spp.), 4 - catfish (Ictalurus spp.), 5 - crappie (Pomoxis spp.), 6 - yellow perch (Perca flavescens), 7 - sauger (Stizostedion canadense), 8 - walleye (Stizostedion vitreum vitreum).

a - coolwater reservoir, b - warmwater reservoir, c - coolwater natural lake, d - warmwater natural lake.

Zone 2 (Table 14). When the results of this study are compared to other large reservoirs and small natural lakes it can be seen that harvest rates were lower in Lake Francis Case. This may be attributed to heavier fishing pressure and higher catch rates for these other bodies of water.

Mean walleye weights ranged from 482 to 612 g in 1981, and 400 to 897 g in 1982 (Table 15). Average walleye weights for both seasons appeared to be high in the spring, decreased until mid-summer, rose in August, and then decreased to a seasonal low in September (Table 15).

Trip Length, Party Size, and Residency

The mean length of a boat angler day during 1981 (May through September) was 5.7 hours and for the 1982 period it was 5.5 hours (Table 16). There was no significant difference between months for the 1981 period, but in 1982 the month of May was found to differ significantly from all other months. The longer duration of angler day in May of 1982 could be related to heavy fishing pressure in the Zone 1 tail race where a fair catch rate may have stimulated angling interest of boat anglers for a longer period of time relative to the other months.

The mean number of boat anglers per party was 2.6 for the May through September period in 1981 and 2.7 for the 1982 period (Table 17). A Waller-Duncan K-ratio t-test showed the 1981 mean number of anglers per party for the months of May and June were significantly larger than

Table 15. Average weight (grams) of walleye (Stizostedion vitreum vitreum) by month, Lake Francis Case, South Dakota, Zone 2, May through September 1981 and April through September 1982, for the entire reservoir.

	1981	1982
April	-	897
May	612	650
June	557	682
July	520	645
August	573	724
September	482	400
Seasonal	550	665

Table 16. Mean length of a boat angler day by month, and the 1981 and 1982 averages for the months of May through September, Lake Francis Case, South Dakota.

	1981	1982
April	-	5.5
May	5.9	6.6
June	5.8	5.3
July	5.1	4.5
August	5.5	4.7
September	5.4	4.7
October	-	5.1
Yearly average (May - September)	5.7 (n=512)	5.5 (n=895)

those of the months that followed. The larger party sizes of May and June may be related to the higher angling pressure for those months. No significant difference was found to occur among months in 1982. Although, as with mean angler day length, estimates of party size tended to decrease from a high in spring and early summer to lower values in the fall. Nonresidents (i.e. those that traveled further than 25 miles (40 km) to fish) comprised 68.1% of the total boat fishing pressure for the 1981 period and 76.4% of the boat fishing pressure in 1982 (Table 18).

Future Harvest Survey Design

The estimated fishing pressure and angler harvest confidence intervals in this study were wider than those estimated for the Lake Sharpe study (Schmidt 1975). Increasing the number of aerial counts per month for the 1982 sampling period could have narrowed the confidence interval, making the estimates more precise and reducing the chance of making a Type II error.

The number of aerial angler counts made in 1981 was nearly double the number made for the same period in 1982 (Table 1). In 1982 (May through September) the 95% confidence interval for total boat fishing pressure was $\pm$ 48.1%. The 1981 estimate for the same months was more accurate having a 95% confidence interval of $\pm$ 24.5%. Any errors in pressure estimate would be incorporated into the harvest estimate since it is derived from the pressure estimate.

Table 18. Percent breakdown of boat angler origin of trip, distance traveled, in 25 mile (40 km) intervals, for 1981 and 1982, Lake Francis Case, South Dakota.

Distance interval in miles	1981	1982
0 - 25	31.9%	23.6%
26 - 50	10.6%	8.9%
51 - 75	13.8%	12.7%
76 - 100	5.9%	4.2%
101 - 125	21.8%	9.7%
126 - 150	4.3%	19.1%
151 - 175	0.0%	3.6%
176 - 200	3.7%	5.1%
201 and greater	8.0%	13.1%

In 1981 the average number of aerial counts per month for May through September was 11.0. It was 5.8 for the same months in 1982. Doubling the number of flights per period reduced the error square by half. In future surveys I would suggest a minimum of six aerial counts per month. Six counts would allow for a minimum of three samples in each strata, and should provide estimates of sufficient accuracy to allow for confident gauging of fishery management effects on fishing pressure and angler harvest. In addition, a greater number of flights should be scheduled during months which may display high variability among counts (i.e. the vacation months of May, June, and July).

The scheduled starting time of an aerial count should be strictly adhered to in order to maintain a random sample from the daylight hours. If, for example, takeoff times are consistently delayed then estimates would be biased toward the later portion of the day.

In this study, only the count of boat anglers actively fishing when passed over by the survey plane was used to estimate fishing pressure. There is some question as to whether or not counts of boat anglers identified as non-active (i.e. fishing line not in the water when surveyed) should be considered when making fishing pressure estimates. On Lake Francis Case boat anglers were observed fishing a point, then pulling in their lines, moving to the next point, and resuming active fishing. This moving time is considered by anglers as active fishing time and is included in the time spent fishing obtained

from angler interviews. Therefore in future surveys one should consider including angler counts from non-active fishing boats in the estimate of fishing pressure if the same fishing technique is observed.

The person making the counts should do so throughout the study. Interpretation of fishing (active or non-active) and non-fishing boats and/or shore anglers may vary among individual counters possessing different degrees of expertise.

Schmidt (1975) warned against the use of a non-uniform probability sampling technique where access points would be surveyed in proportion to the amount of pressure expected at each. He based this on a one month sample in May of 1973, and concluded that the heavily used areas tended to have higher catch rates than the lesser used areas and therefore a non-uniform sampling design would tend to bias the catch rate estimate upward.

During the month of May in this study catch rates were high in both 1981 and 1982; in particular this occurred in the upper stretches of Zone 1 in the area of the Big Bend Dam tail race. Observations of this study were that angler pressure was high during periods of high catch rates of preferred species. In addition, areas of high catch rate were observed to have more visitation. Since these areas receive a greater effort from a wide range of angler expertise they would tend to be more representative of the average angler. In addition, concentration of interview effort during times and in areas of high angler visitation

avoids wasted sampling effort (Taylor and Carroll 1964). This is not to say that areas of low use should not be sampled, but that they should receive less weight when sampling effort is scheduled.

Significant differences in catch rates occurred between estimates obtained from completed and noncompleted boat angler interviews for some of the within-month comparisons. For this reason, only the information from completed boat angler interviews was used to estimate catch rates. Since significant differences between completed and noncompleted shore anglers occurred less frequently and because of the difficulty of obtaining completed shore angler interviews, all shore angler interviews were used to make estimates of catch rates.

The methods employed in this study were suited to the conditions encountered on Lake Francis Case, South Dakota. These methods could be easily adapted to other large reservoirs which contain several points of access, and when compared with past creel survey methods give precise estimates of fishing pressure and harvest with a relatively small amount of manpower.

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APPENDIX

Appendix Table 1. Analysis of variance of the mean number of anglers per count, Lake Francis Case, South Dakota, May through October 1981.

Source of variation	d.f.	Mean squares	F value
A (month)	5	20,870.2	5.5*
B (type of day)	1	9,559.7	2.5
C (type of fishing)	1	94,007.1	24.8*
A * B	5	7,011.7	1.9
A * C	5	15,121.1	4.0*
B * C	1	6,798.1	1.8
A * B * C	5	6,066.2	1.6
ERROR	96	3,787.6	

* Significant at the 0.05 probability level.

Appendix Table 2. Calculated least squares means of the significant interaction month by type of fishing for the number of anglers per count, Lake Francis Case, South Dakota, May through October 1981.

Month	Type of fishing	Least squares mean
May	Boat	155.8
	Shore	13.0
June	Boat	132.6
	Shore	9.9
July	Boat	28.1
	Shore	1.9
August	Boat	33.3
	Shore	2.8
September	Boat	40.7
	Shore	3.3
October	Boat	4.4
	Shore	0.5

Appendix Table 3. Analysis of variance of the mean number of anglers per count, Lake Francis Case, South Dakota, April through October 1982.

Source of variation	d.f.	Mean squares	F value
A (month)	6	33,209.3	12.0*
B (type of day)	1	36,510.0	13.2*
C (type of fishing)	1	145,985.2	52.7*
D (zones)	2	11,370.6	4.1*
A * B	6	6,406.5	2.3*
A * C	6	25,143.8	9.1*
A * D	12	4,407.5	1.6
B * C	1	19,028.3	6.9*
B * D	2	1,247.4	0.5
C * D	2	5,471.1	2.0
A * B * C	6	6,052.3	2.2*
A * B * D	12	831.9	0.3
A * C * D	12	3,687.0	1.3
B * C * D	2	1,325.0	0.5
A * B * C * D	12	622.9	0.2
ERROR	144	2,772.6	

* Significant at the 0.05 probability level.

Appendix Table 4. Calculated least squares means of the significant interaction month by type of day by type of fishing for the number of anglers per count, Lake Francis Case, South Dakota, April through October 1982.

Month	Type of day	Type of fishing	Least squares mean
April	Weekday	Boat	9.2
		Shore	0.0
	Weekend	Boat	45.2
		Shore	17.1
May	Weekday	Boat	94.8
		Shore	3.8
	Weekend	Boat	103.2
		Shore	21.7
June	Weekday	Boat	96.9
		Shore	7.8
	Weekend	Boat	231.6
		Shore	21.2
July	Weekday	Boat	34.8
		Shore	4.7
	Weekend	Boat	146.7
		Shore	5.0
August	Weekday	Boat	15.0
		Shore	4.5
	Weekend	Boat	29.0
		Shore	5.3
September	Weekday	Boat	9.1
		Shore	1.3
	Weekend	Boat	27.7
		Shore	4.2
October	Weekday	Boat	4.0
		Shore	1.0
	Weekend	Boat	4.9
		Shore	1.0