# Methods

## Creel Survey Design

We conducted a modified access-point creel survey on the LWR, based on the bus route design developed by Robson and Jones (1989). In this design, the creel clerk visits a number of access sites during each sampled day, following a prescribed route with prespecified arrival and waiting times at each site on the route. The starting location and direction are randomly selected each day. This design was developed for fisheries that cover a large geographic area including many access sites with large differences in fishing effort. In the traditional access-site design, the creel clerk spends an entire shift at one access site. The bus route design can provide more precise estimates than the traditional design when within-day use of sites differs, and when waiting times at sites in the route are long enough to obtain completed trip interviews (Jones and Robson 1991).

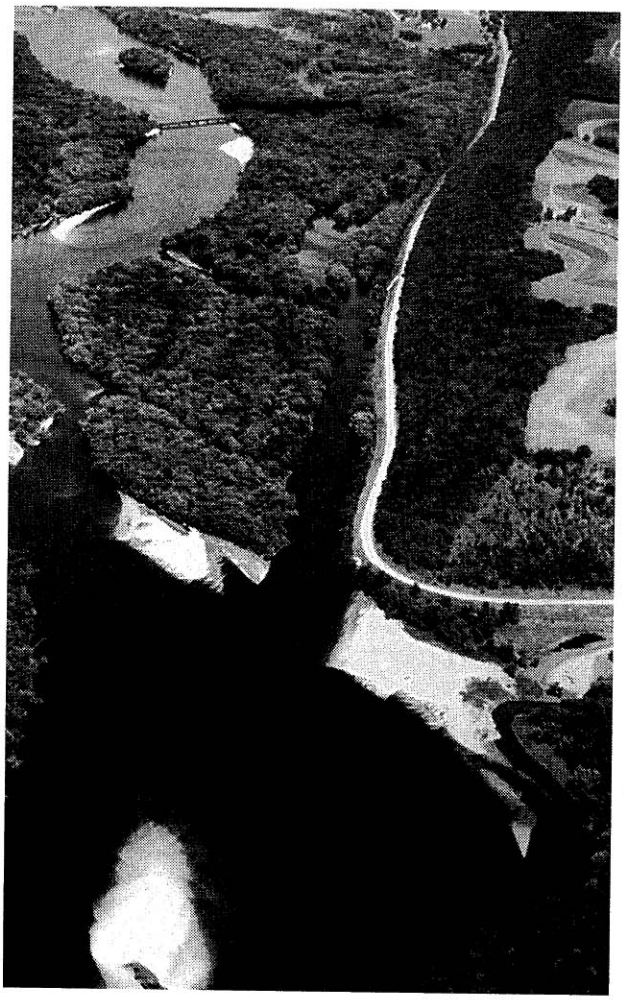

PHOTO: DAVE GREENE

*A multitude of islands, shifting sandbars, and backwaters characterize the typical habitat of the SPG, MUS, and WZK zones. This view is from the WZK zone, looking upstream from near the mouth of the Big Green River (which is visible in the lower right).*

The 4 zones of the LWR resulted in 3 routes of approximately equal length, and one shorter route for the most heavily used section of the river immediately below the Prairie du Sac Dam. All routes required 2 work shifts to complete, except for the PDS zone during winter, when some access sites were inaccessible or not used by winter anglers. One full-time (40 hours/week) creel clerk was assigned to each route. The PDS zone route was surveyed from 4 January 1990 to 19 October 1991. The other 3 zones were surveyed from 11 March to 20 October 1990. The survey occurred primarily during daylight hours and was stratified by shift (a.m. vs. p.m.), day of week (weekday vs. weekend/holiday), and by 4-week period beginning 14 January 1990. Shift length was defined as fishing day length divided by 2, and thus varied among time periods. The sampling probability for the a.m. shift was half that for the p.m. shift. Sampling probabilities were larger for weekends than for weekdays and varied somewhat among time periods, but we usually sampled 3 of every 5 weekdays and all weekend days and holidays. Waiting times at each site were assigned in proportion to the expected fishing effort at each site and ranged from 30-45 min at low use sites to 1.5-2 hours at high use sites, depending on the number of sites in the route and the travel time between sites. Site waiting times varied among time periods as site use changed and information about site use improved.

Jones and Robson (1991) suggested that when sites are used primarily by anglers, counts of cars at access sites give more precise estimates of effort than do completed trip interviews. We were unable to use the car count method because many access sites were used by a wide variety of people, including canoeists, swimmers, sunbathers, campers, hunters, birders, hikers, and others, and the clerks interviewed only returning anglers and boaters. We increased our information about effort beyond that obtained from interviews by making instantaneous counts of shore anglers and counting both starting and ending boat trips at each site. The same procedures were used successfully in a DNR creel survey of Lake Mendota, Wisconsin (Johnson and Staggs 1992).

On the LWR, the clerk obtained party size, number of anglers, number of boats used, and trip duration from all interviewed parties. From angling parties, the clerk obtained numbers caught and harvested of each species, lengths of harvested fish, weights and tag numbers for tagged fish, species targeted, distance traveled, bait used, and sex of anglers. Interviews of accessible anglers (primarily shore anglers) at the end of the waiting time at a site resulted in some incomplete trip interviews.

## Creel Survey Computations

We used instantaneous counts of shore anglers and cumulative counts of boat trips with data from completed trip interviews for estimation of effort, catch, and harvest (Johnson and Staggs 1992). Site waiting times were used in expanding effort to an entire route (Robson and Jones 1989). Initial effort computations were done separately for each stratum (shift, day type, and time period). Because there were few completed trip interviews in some 4-week survey periods for the SPG and MUS zones, we grouped the 4-week survey periods into 8-week strata for all computations that involved data from interviews. We retained one 4-week period from 21 October to 17 November 1990 because the 52-week year does not divide evenly into 8-week periods, and we wanted to make annual estimates of effort and harvest for 1990 in the PDS zone. This grouping of periods also resulted in the same time periods for 1990 and 1991, and simplified comparisons between years in the PDS zone.

The remainder of the calculations follow the methods described by Johnson and Staggs (1992). Computations were done separately for each stratum (shift, day type, and time period) and estimates were added across strata. When angling by a party occurred in more than one stratum, that party was assigned to the stratum during which the interview took place. Shore angler effort in angler hours was estimated from instantaneous counts of shore anglers. Boat angler effort in trips was computed from cumulative counts of boat trips (the average of starting and ending trips), corrected for the proportion of boat parties that were angling (based on interviews). Effort in boat trips was converted to angler hours by multiplying by the average trip hours per boat angler. Shore angler catch and harvest were estimated as the product of shore angler hours and catch or harvest per hour. Boat angler catch and harvest were estimated as the product of boat angler trips and catch or harvest per trip. Variances of products were calculated using the standard formula described by Goodman (1960). The variances of catch and harvest rate for shore anglers were calculated using the formula for the variance of a ratio (Cochran 1977: 155) with the finite population correction set to one.

## Creel Survey Summaries

We summarized the creel survey results over several time periods because the duration of the survey varied among zones. We used summaries over the period from 11 March to 20 October 1990 for comparisons among zones because this was the only time during which all zones were surveyed. We used the 8-week estimates described above to portray seasonal variations in effort and harvest in the PDS zone. We compared effort and harvest between years in the PDS zone using estimates for two 40-week periods, from 14 January to 20 October 1990, and from 13 January to 19 October 1991. We calculated annual effort and harvest in the PDS zone for 14 January 1990 to 12 January 1991. We also computed annual estimates for the entire LWR by adding the total for the downstream zones to the annual 1990 estimate for the PDS zone. We assumed that most of the downstream angling pressure was during our survey period. Because the downstream zones, especially the WZK zone, are fished until late November, the annual estimate for the entire LWR is an underestimate.

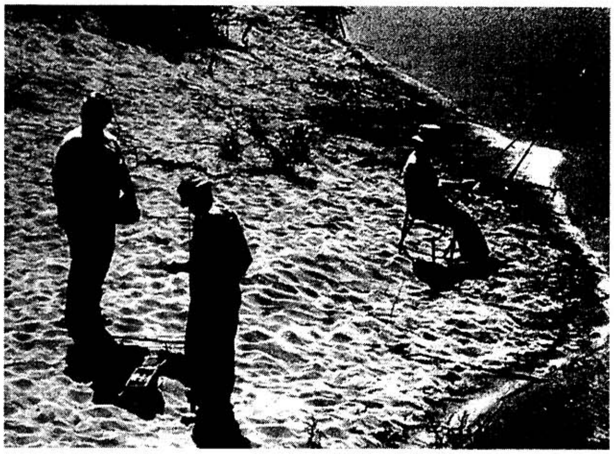

PHOTO: JEAN UNMUTH

*A WDNR creel clerk interviews catfish anglers below the Muscoda bridge (MUS zone).*

## Exploitation

We calculated angling exploitation rates for walleye $\geq$ 15 inches and sauger $\geq$ 10 inches for the periods fall 1989 through spring 1990 and fall 1990 through spring 1991 in the PDS zone. Walleye $\geq$ 15 inches and sauger $\geq$ 10 inches were tagged with individually numbered t-bar tags in October and November 1989 and again in October and November 1990. We calculated exploitation as the estimated number of tagged fish harvested, based on the creel survey, divided by the number of fish tagged in the preceding fall. Because exploitation of fish tagged in fall 1989 occurred prior to the beginning of the creel survey in January 1990, we generated our 1989-90 exploitation estimate based in part on 1990-91 results. We determined the ratio of the estimated number of tagged fish harvested from October-December 1990 to the estimated number harvested from January-May 1991, and then applied this ratio to the January-May 1990 data to estimate the total harvest of tagged fish during October-December 1989. We then used the total estimated harvest of tagged fish from October 1989 through May 1990 to calculate exploitation. We did not factor tag loss into our calculations, although we suspected that it occurred, and thus our exploitation values could be underestimates.

## Modeling Regulation Changes

We used the creel survey results to model the possible effects of closed fishing seasons, reduced bag limits, and increased minimum size limits on angler harvest of walleye and sauger in the PDS zone. During 1990 and 1991, there was no closed season for walleye and sauger in the LWR, the bag limit was 5 walleye and sauger in aggregate, there was no minimum size limit for sauger, and there was a 15-inch minimum length limit for walleye, newly enacted on 1 January 1990, after many years with no size limit. The procedure we used to calculate the effects of various closed seasons was straightforward. From the creel survey, walleye and sauger harvests were estimated for six 8-week periods and one 4-week period between 14 January 1990 and 13 January 1991. We calculated the percent decrease in total annual harvest that would occur if the fishing season had been closed (i.e., harvest had been zero) during one or more of these periods. For simplicity, we made the assumption that no harvest compensation took place during the open fishing season. In other words, we assumed that fish that were spared from harvest because of the closed season would not then be harvested later in the year after the closed season had ended. We also assumed that illegal harvest during the closed season would be negligible. These assumptions were probably unrealistic, and our analysis likely estimated the maximum decrease in harvest caused by a closed season. We examined closures between late October and early May, as this was a period when most angling effort was targeted specifically towards walleye and sauger and when catch and harvest were high.

The procedure that we used for estimating the effects of different bag limits was more complex. We used data on the observed distribution of harvest among anglers for the entire creel survey period. To examine the effect of reduced bag limits on total harvest, we "censored" the observed harvest distribution (Staggs 1989, Wagner and Orth 1991) under all possible lower bag limits. This involved hypothetically decreasing the bag of all anglers who had actually harvested more than the proposed new bag limit, calculating the new total harvest of these anglers, adding this new total harvest to the total harvest of those anglers who had actually harvested at or below the proposed bag limit, and comparing this sum with the actual observed total harvest of anglers under the current 5 fish bag limit. We assumed that the distribution of harvest among anglers during 1990-91 was representative of other years, that a reduced bag would not lead to a decrease in fishing pressure, that harvest in excess of the legal bag limit was negligible, and that no harvest compensation would take place, i.e., that those fish removed from the harvest of one set of anglers by the new bag limit would not then be harvested by a different set of anglers. All of these assumptions were probably somewhat unrealistic, and violations of them could result in either greater or lesser declines in harvest than we predicted.

The procedure that we used to estimate the effects of different minimum size limits was also straightforward. We first determined the size distribution (by inch group) of the harvest for both species. Because size distributions were very similar between 1990 and 1991, we combined the data from the 2 years. We then calculated the percentage of the distribution that would be protected from harvest if the minimum size limit were raised to a particular level. We made several major assumptions in this analysis. First we assumed that the 1990-91 data represented a stable size distribution. However, because a minimum size limit had just been implemented in 1990, the size distribution of walleye actually may have been in transition. Also, yearly variation in recruitment might cause changes in walleye and sauger size distributions. Second, we assumed that illegal harvest would be constant and limited, although we suspected that the frequency of illegal harvest might increase under a higher minimum size limit. We also assumed that hooking mortality of fish under the size limit was negligible. However, studies indicated that hooking mortality could sometimes be significant, particularly when fish were captured with live bait (Payer et al. 1989, Shaefer 1989). Finally, we assumed that no harvest compensation would take place. In other words, we assumed that protecting a greater proportion of the population with a higher minimum length limit would not cause increased harvest of the remainder of the population that could still be legally harvested. Violations of these assumptions could lead to either under- or over-estimates of the change in harvest likely under increased minimum size limits.

# Results

## Biases in the Creel Survey

We identified 4 possible sources of bias in the creel survey that must be evaluated before considering the results and implications of the survey. These biases generally resulted in underestimates of angler effort and harvest, although their magnitude was unknown.

**Private Access Sites**. We did not attempt to interview anglers at most of the many private access sites on the river. The creel clerk counted shore anglers and starting and completing boat trips from private access sites in the PDS zone only. Effort and harvest for the other zones were underestimated because we have no information on private access sites.

**Shore Anglers**. Shore angling effort is underestimated in all zones except PDS because the clerk could see only a small section of the river from each access site, and could not see all shore anglers. The spacing and location of access sites in the PDS zone allowed the creel clerk to count shore anglers throughout the entire zone; the clerk counted shore anglers in a specified area from each access site to prevent double counting.

**Movement Between Zones**. Canoeists typically make one-way trips on the river, putting in at an upstream site and taking out at a downstream site. Many canoeists are not anglers. One of the most popular canoe runs is from a site in the PDS zone to one of several sites in the SPG zone. These canoeists could be counted as starting boat trips in the PDS zone, and interviewed and counted as completing trips in the SPG zone. Because estimates of the proportion of boat trips that are angling are based on interviews, this proportion is overestimated in the PDS zone and underestimated in SPG. This in turn results in overestimates of effort and harvest for PDS, and underestimates for SPG. This bias exists only in the summer when there is substantial canoe use of the river.

**Night Angling**. The creel survey was designed to estimate angling effort and harvest during daylight hours. During the summer (June-August), we randomly reassigned each clerk to run 3 late-night shifts during each 4-week sampling period. Although this level of survey effort was enough to indicate that angling occurred through the night, and gave us some information on species targeted, it was not sufficient to estimate late night effort or harvest. For every zone except MUS, the number of starting boat trips counted during the daytime shifts was consistently greater than the number of completing boat trips counted, indicating that anglers were still on the river after the end of the p.m. shift. Because we have based our boat effort estimates on the average of starting and completing trips, some of the effort estimated represents boat anglers who continued fishing after the end of the p.m. shift, although night angling effort is still underestimated by this method.

## Survey Effort

The creel survey had 1,070 days of clerk effort, resulting in 2,191 completed trip interviews. Approximately two-thirds of all possible days were sampled for each zone. The majority of interviews were from the PDS zone (Table 1). There were more shore-angler than boat-angler interviews for all zones except MUS, but most shore-angler interviews were of one angler whereas most boat-angler interviews were of parties of 2 or more anglers.

## Angler Effort

During 1990, angling effort was highest in the PDS zone (Table 2). Almost half (46%) of all the angler hours estimated on the LWR between 11 March and 20 October 1990, occurred in the PDS zone. Twenty-six percent of the angler hours during this