A creel survey of the lower Wisconsin River, 1990-1991. Report 160 [1994]

Rasmussen, Paul W., et al.
Madison, Wisconsin: Wisconsin Dept. of Natural Resources, [1994]

WISCONSIN DEPARTMENT OF NATURAL RESOURCES

RESEARCH REPORT 160

April 1994

A Creel Survey of the Lower Wisconsin River, 1990-1991

by **Paul W. Rasmussen, Jean M. L. Unmuth, and John Lyons**
Bureau of Research, Monona

and Gene Van Dyck
Bureau of Fisheries Management, Dodgeville

Abstract

During 1990 and 1991, the Wisconsin Department of Natural Resources conducted a "bus route" modified access-point creel survey of anglers over 90.4 miles of the Lower Wisconsin River (LWR). For survey purposes, the LWR was divided into 4 study areas: the short Prairie du Sac (PDS) zone immediately below the Prairie du Sac dam, and the longer Spring Green (SPG), Muscoda (MUS), and Wauzeka (WZK) zones, which encompassed the rest of the LWR down to the Mississippi River. The PDS zone was surveyed from 14 January 1990, to 19 October 1991, whereas the other zones were surveyed only from 11 March to 20 October 1990. Angling effort was highest in the PDS zone. From March through October 1990, effort was 147 hours/acre in the PDS zone, 8 hours/acre in the SPG zone, 5 hours/acre in the MUS zone, and 17 hours/acre in the WZK zone. For the PDS zone, effort was 171 hours/acre in January-December 1990, 159 hours/acre during January-October 1990, and 147 hours/acre during January-October 1991. Over the entire LWR, anglers targeted walleye/sauger, "anything", channel catfish, smallmouth bass, white/yellow bass, bluegill, and unspecified gamefish, although the most heavily targeted species varied among the 4 zones, and seasonally in the PDS zone. Anglers interviewed during the survey caught 47 fish species and harvested 35. Mean angler catch rate was 1.1 fish/hour, and 58% of anglers caught at least 1 fish. Mean harvest rate was 0.6 fish/hour, and 32% of anglers harvested at least one fish. Over the entire LWR, the species with the largest catch and harvest were bluegill, channel catfish, white/yellow bass, freshwater drum, walleye, smallmouth bass, and sauger. Catch and harvest rates for most species peaked in summer. However, in the PDS zone, catches of walleye and sauger were greatest between mid-October and early May, harvest of walleye peaked during early May and June, and harvest of sauger peaked between mid-November and early March. In the WZK zone, the maximum catch and harvest of walleye and sauger occurred between late August and mid-October. Over the entire LWR, sauger as small as 9 inches were harvested, and most were below 15 inches. The majority of walleye harvested were 15-19 inches long, just above their 15-inch minimum length limit, and most smallmouth bass harvested were 14-17 inches, just above their 14-inch limit. Some harvest of sub-legal walleye and smallmouth bass was observed. Most white/yellow bass harvested were 10-14 inches, and most channel catfish were 11-15 inches. The largest bluegill observed in angler creels was 9 inches, and most were 6-8 inches. In the PDS zone, estimated exploitation rates were 16% for walleye and 35% for sauger from fall 1989 through spring 1990, and 51% for walleye and 56% for sauger from fall 1990 through spring 1991. Modeling using survey results indicated that increased minimum size limits would be the most effective way to decrease walleye and sauger harvest. Management recommendations resulting from this creel survey are: (1) conduct another creel survey of the LWR to identify trends in the fishery, (2) learn more about bluegill, white/yellow bass, and freshwater drum population dynamics and interactions with other species in the LWR, and (3) if a declining trend in walleye or sauger abundance or size structure becomes apparent, implement more restrictive size limits to reduce angler harvest.

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Introduction

The Lower Wisconsin River (LWR) is one of the most important natural and recreational resources in Wisconsin. It has a wide range of high-quality habitats that support a diverse fish fauna (Wis. Dep. Nat. Resour. 1988, Fago 1992), including numerous gamefish and panfish species that sustain fisheries, and several state threatened and endangered species. The LWR is used by many Wisconsin residents and nonresidents for numerous recreational pursuits, of which angling is one of the most important. In recognition of its unique attributes, the LWR and its riparian corridor between the Prairie du Sac Dam and the Mississippi River were declared the first Wisconsin State Riverway in 1989. As a State Riverway, the LWR receives special legal protection and additional resource management efforts from the Wisconsin Department of Natural Resources (DNR).

Although sport angling is clearly a major activity in the LWR, prior to 1990, little was known about the magnitude, distribution, composition, and seasonal pattern of angling effort, catch, and harvest. A 1985 creel survey yielded valuable information on the summer fishery in the LWR, particularly for channel and flathead catfish (see Appendix A for scientific names of fishes). However, because of the survey's design and objectives, estimates of overall angling effort and catch were imprecise, and limited to the warmer months of the year (T. Pellett, DNR, personal communication). No data were collected during the important fall, winter, and spring fisheries that occur in certain areas of the LWR.

In the absence of adequate information on the LWR fishery, effective fishery management was hindered. Recognizing this, DNR Fisheries Management and Fish Research personnel initiated a detailed creel survey of the LWR in 1990. This survey was designed to provide precise estimates of angling effort, catch, and harvest during all portions of the year when substantial amounts of angling took place. The survey was a cooperative effort, with Fisheries Management providing funding and field assistance for the survey through the DNR Dodgeville office, and Fish Research supervising the survey and analyzing the results. In this report, we summarize the major findings and implications of the survey.

In addition to creel survey data, biological information on important sportfish species has also been collected from the LWR in recent years. During the mid-1980s, extensive data were obtained on abundance, movement patterns, size structure, age distribution, and growth of channel and flathead catfish. During the late 1980s, similar data were collected for walleye and sauger, and to a lesser extent northern pike, hybrid muskellunge, and smallmouth and largemouth bass. Since 1987, annual surveys of the size structure and reproductive success of walleye and sauger have occurred in the area below the Prairie du Sac Dam. All of these studies complement the creel survey data, and manuscripts will be prepared describing study results.

Study Area

The Wisconsin River originates in Vilas County on the Wisconsin-Michigan border. It is the longest river wholly within Wisconsin, flowing 425 miles south and west to where it empties into the Mississippi River near Prairie du Chien, Wisconsin, and draining an area of 12,000 miles^2 (Henrich and Daniel 1983). There are 21 storage reservoirs and 26 dams on the river. The lowermost dam on the river is located at Prairie du Sac. Construction of this dam began in 1911 and was completed in 1914. The dam has a head of 41 ft and is used for hydroelectric power production. It is impassable to fish moving upstream, although fish move downstream through it, particularly during high flows when the flood gates are open.

In this paper, we define the LWR as the westerly flowing 92.3 mile stretch of river from the Prairie du Sac dam to the confluence with the Mississippi River. The LWR comprises nearly one-fourth of the total watershed area of the Wisconsin River. The LWR is generally wide (>600 ft) and relatively shallow (<6 ft), with a shifting sand substrate. However, immediately below the dam there is a pool > 35 ft in depth with extensive areas of rocky substrate, although sand still dominates the river bottom. During 1990 and 1991, mean discharge was 7,470 cfs at the Prairie du Sac Dam (Wis. Power and Light Corp., unpublished data), and 8,120 cfs at Muscoda (Holmstrom et al. 1992). The highest discharge recorded at Muscoda during the survey was 32,200 cfs on 7 June 1991, and the lowest was 2,500 cfs on 2 January 1990. Typically, flows in the LWR are highest in early spring and summer and lowest in midwinter and late summer. Average water temperature is approximately 70 F in June and 32 F in December (Holmstrom et al. 1992). Summer temperatures often exceed 80 F. During January and February, ice usually prevents angling from the railroad bridge in Sauk City down to the mouth of the river. Angling is possible all year immediately below the dam.

Water quality in the LWR is usually good. Treated sewage and agricultural runoff are the primary sources of pollution, sometimes causing high turbidity and locally elevated fecal coliform levels. Dissolved oxygen levels below the Prairie du Sac Dam sometimes drop below the state water quality standard minimum of 5 mg/L (Wis. Dep. Nat. Resour. 1988). Nutrient levels in the LWR are moderate compared to other large rivers in Wisconsin. Conductivity ranges from 195-326 µS/cm, pH from 7.5-9.0, turbidity from 1.5-46 NTU, and hardness from 75-150 mg/L as $CaCO_3$ (Holmstrom et al. 1992).

The LWR area is largely agricultural, with low intensity rural development. River recreational facilities are moderately well developed. Fifteen small towns are located along the river banks, as well as 2 state parks and 16 state wildlife areas. There are 24 boat or canoe public access points, and 30 public shore angling sites accessible directly by road. Many more public and private access points can be reached only by foot or all-terrain vehicle. Canoe and boat liveries and bait and tackle shops are found in many of the towns on or near the LWR.

There is a high diversity of aquatic fauna associated with the LWR, including many types of fish, frogs, salamanders, lizards, snakes, turtles, and clams. Thirty-four species of clams occur in the river, constituting one of the richest mussel faunas in the state (Wis. Dep. Nat. Resour. 1988). Because of the great variety of habitats along the river, ranging from dry prairies to bottomland hardwoods and marshes, many species of upland game birds, songbirds, waterfowl, furbearers, reptiles, and amphibians have been sighted within the river corridor and documented. The fish fauna is particularly diverse. Fago (1992) reported 87 fish species from surveys of the entire LWR during

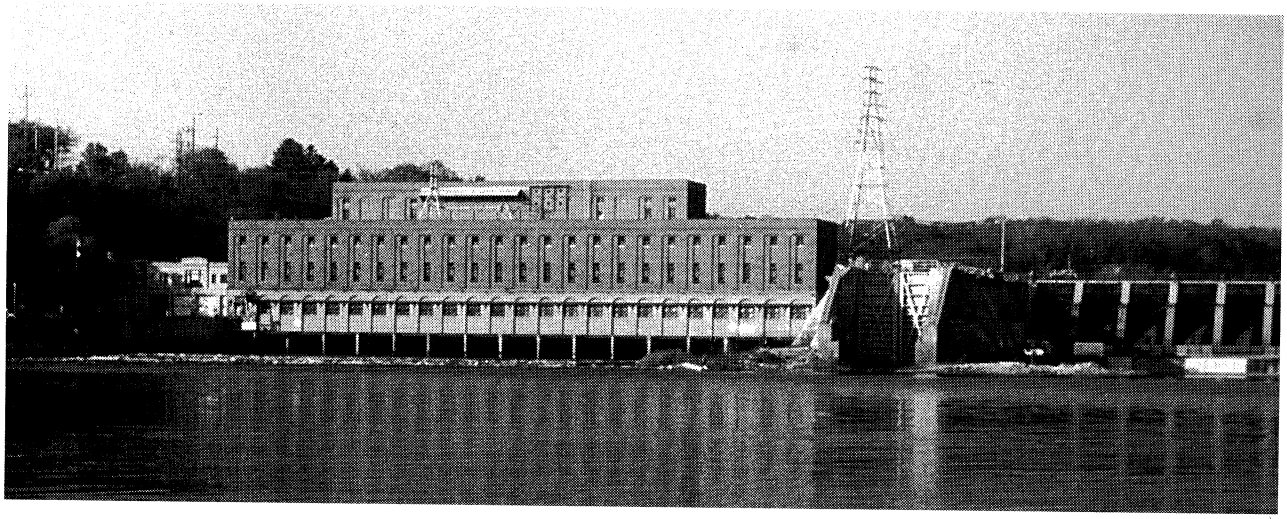

PHOTO: JOHN LYONS

The hydroelectric dam at Prairie du Sac marks the upper end of the Lower Wisconsin River and forms the upper boundary of the PDS zone. The rapids and deep tailwater pool below the powerhouse coupled with extensive areas of rocky substrate create unique habitat conditions in the PDS zone that attract a wide variety of fishes and a large number of anglers.

the late 1970s. One of these species was on the Wisconsin Endangered Species List, 5 were on the Threatened List, and 7 were on the Special Concern List. Between 1985 and 1991, Lyons (DNR, unpublished data) observed 61 fish species near the Prairie du Sac Dam, including 2, the State Special Concern lake sturgeon and the yellow bass, not reported by Fago (1992). During the same time interval, Lyons also collected a State Endangered Species not reported by Fago (1992), the starhead topminnow, in sloughs near Spring Green and Wauzeka.

For study purposes the LWR was divided into 4 zones (Fig. 1). The Prairie du Sac (PDS) zone, which began at the Prairie du Sac Dam and ended just below the railroad bridge in Sauk City, was 3.8 miles long and covered approximately 900 acres at normal water flows. The Spring Green (SPG) zone, which started below the railroad bridge in Sauk City and ended near Cynthia Slough below the State Highway 23 bridge near Spring Green, was 25.4 miles long and covered 4,710 acres. The Muscoda (MUS) zone, which began at the Otter Creek boat landing (Iowa County) just above the State Highway 133 bridge near Lone Rock and ended at the Boscobel bridge, was 33.0 miles long and covered 7,990 acres. The Wauzeka (WZK) zone, which began just below the Boscobel bridge and ended at the railroad bridge below the State Highway 18/35 bridge, was 28.2 miles long and covered 4,510 acres. We did not include the final 1.9-mile stretch between the Mississippi River and the railroad bridge in the WZK zone because many of the anglers in this stretch put in at access sites on the Mississippi River and thus were not interviewed by our clerk.

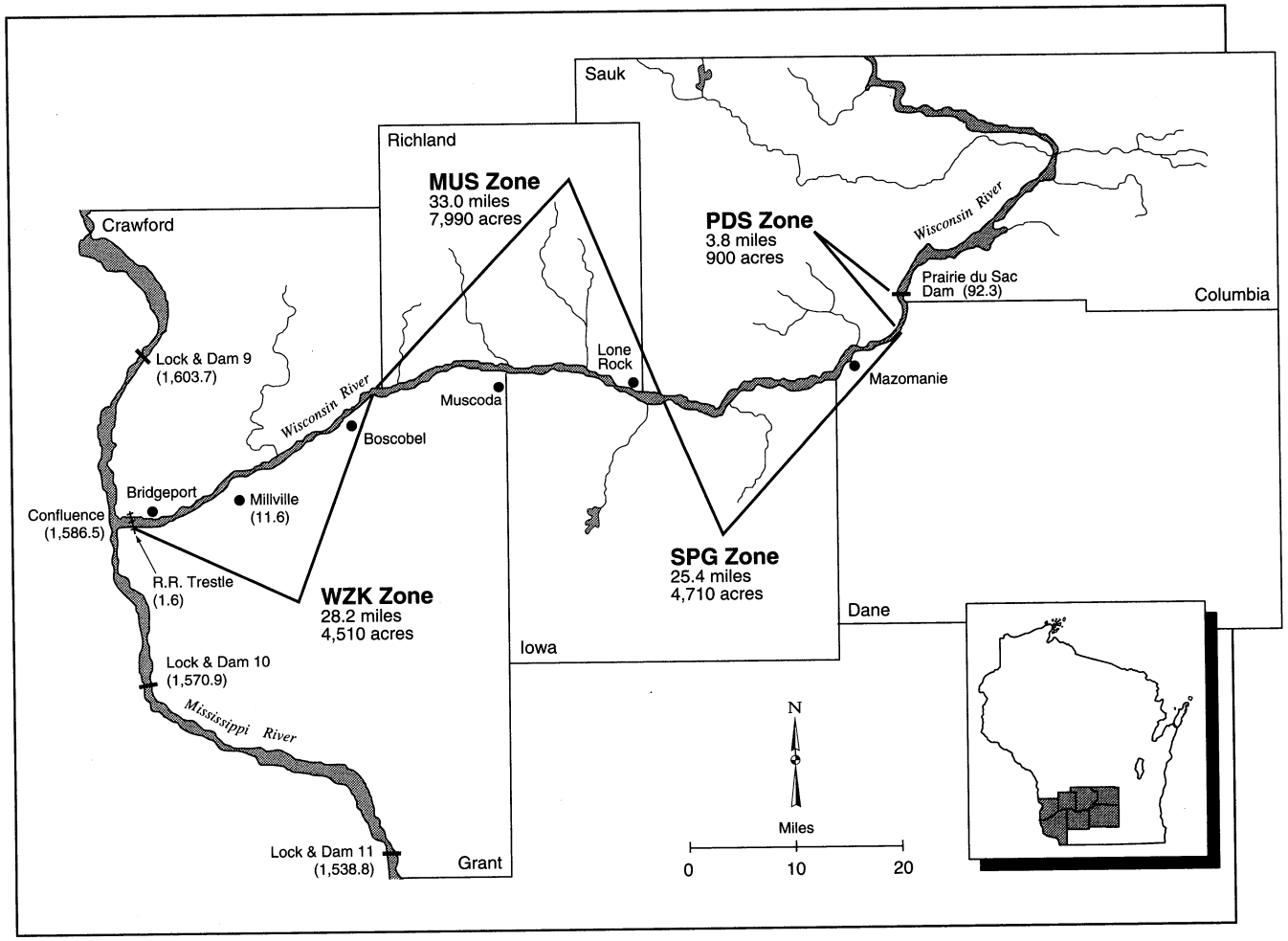

Figure 1. *The Lower Wisconsin River and vicinity, showing study zones, miles and surface acres of water within each zone, and key locations with river miles in parentheses (distance upstream from the mouth of the river, Fago 1988).*

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).

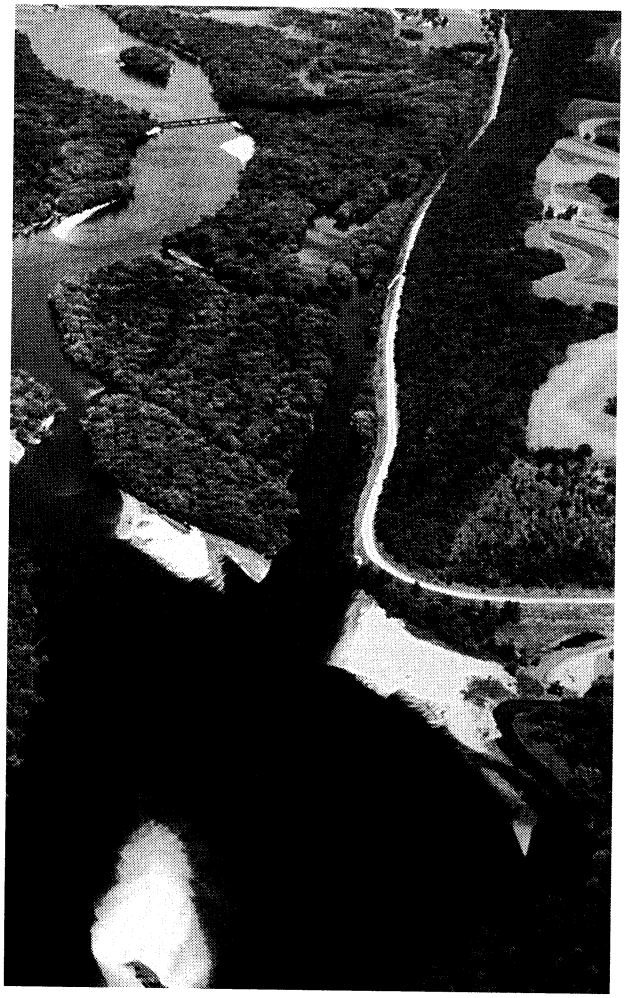

PHOTO: DAVE GREENE

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 ≥ 15 inches and sauger ≥ 10 inches for the periods fall 1989 through spring 1990 and fall 1990 through spring 1991 in the PDS zone. Walleye ≥ 15 inches and sauger ≥ 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

Table 1. *Number of days surveyed and completed trip interviews.*

Zone and Study Period	Total Days	Days Surveyed	Completed Trip Interviews			
			Shore Angling	Boat Angling	Boat Nonangling	Total
11 Mar-20 Oct 90						
Prairie du Sac	224	149	170	533	20	723
Spring Green	224	142	72	35	82	189
Muscoda	224	141	32	75	1	108
Wauzeka	224	143	78	130	16	224
Total	896	575	352	773	119	1,244
14 Jan 90-12 Jan 91						
Prairie du Sac	364	249	653	245	20	918
14 Jan-20 Oct 90						
Prairie du Sac	280	189	576	210	20	806
13 Jan-19 Oct 91						
Prairie du Sac	280	186	475	262	15	752

period were in the WZK zone, and the remainder were divided between the middle 2 river zones, the SPG and the MUS. Seasonal patterns were similar among zones, with peak effort occurring during July and early August (Fig. 2). The proportion of total angling effort by boat anglers was highest in the SPG zone and lowest in the MUS zone (Table 2), although shore angling effort is probably underestimated in all but the PDS zone. Nonangling boat use was highest in the SPG and PDS zones, although use per mile was higher in the PDS zone.

The amount and seasonal distribution of angling effort in the PDS zone was similar in 1990 and 1991 (Table 2, Fig. 3). In both years, angling effort was lowest but still substantial in midwinter, increased steadily over the spring and early summer to its highest levels in July and early August, and then declined through fall into winter.

The proportion of total angling effort targeted at various species groups varied among zones (Fig. 4). In the PDS zone, most effort was directed towards walleye/sauger, and the remainder at bluegill, white/yellow bass, channel catfish, and smallmouth bass. Anglers in the SPG zone directed their effort approximately equally at smallmouth bass and walleye/sauger. Most of the effort in the MUS zone was targeted at "anything," and the remainder was approximately equally divided among walleye/sauger, channel catfish, and gamefish. In the WZK zone, nearly half of the effort was directed at channel catfish, one-quarter at "anything," and most of the remaining effort at walleye/sauger and smallmouth bass.

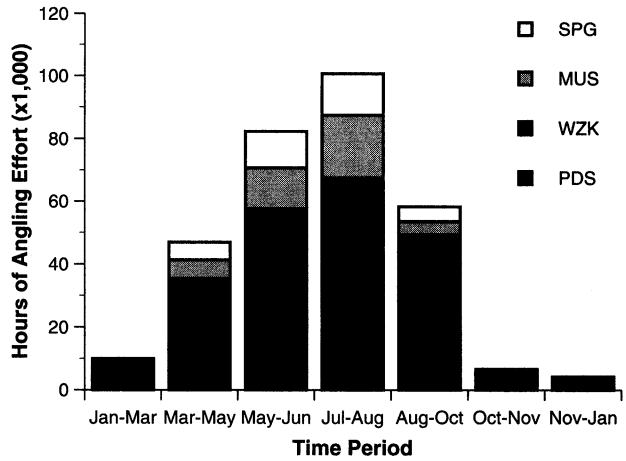

Figure 2. *Temporal distribution of angling effort in the LWR in 1990. In this and subsequent figures, all time periods were 8 weeks long except October-November, which was 4 weeks long.*

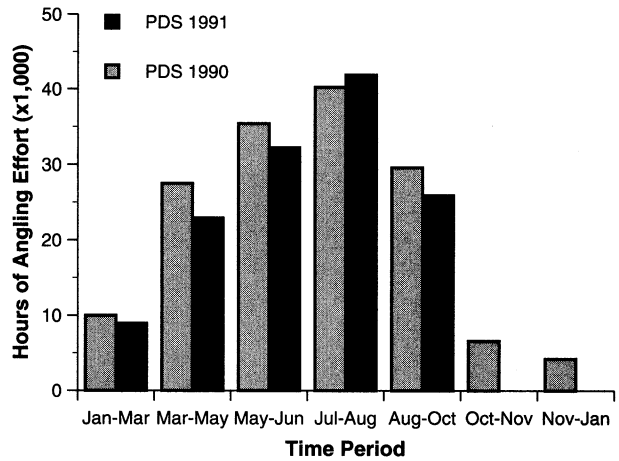

Figure 3. *Temporal distribution of angling effort in the Prairie du Sac (PDS) zone in 1990 and 1991. Note that the creel survey ended 19 October 1991.*

Table 2. *Angler effort estimates.*

Zone and Study Period	Angling Hours					Nonangling Hours	
	Total	Standard Error	Per Acre	Per Mile	Percent by Boat	Boat	Standard Error
11 Mar-20 Oct 90							
Prairie du Sac	132,632	13,055	147.4	34,903	58.6	58,687	11,345
Spring Green	35,111	5,497	7.5	1,382	78.7	85,865	15,248
Muscoda	43,398	4,684	5.4	1,451	43.8	285	No data
Wauzeka	77,026	8,634	17.1	2,576	60.9	22,421	4,122
Total	288,167	17,238	15.9	3,122	59.4	167,25	19,447
14 Jan 90-12 Jan 91							
Prairie du Sac	154,496	13,286	170.6	40,394	60.5	58,687	11,345
14 Jan-20 Oct 90							
Prairie du Sac	142,637	13,204	158.5	37,536	60.4	58,687	11,345
13 Jan-19 Oct 91							
Prairie du Sac	131,846	10,997	146.5	34,696	58.3	42,073	12,748

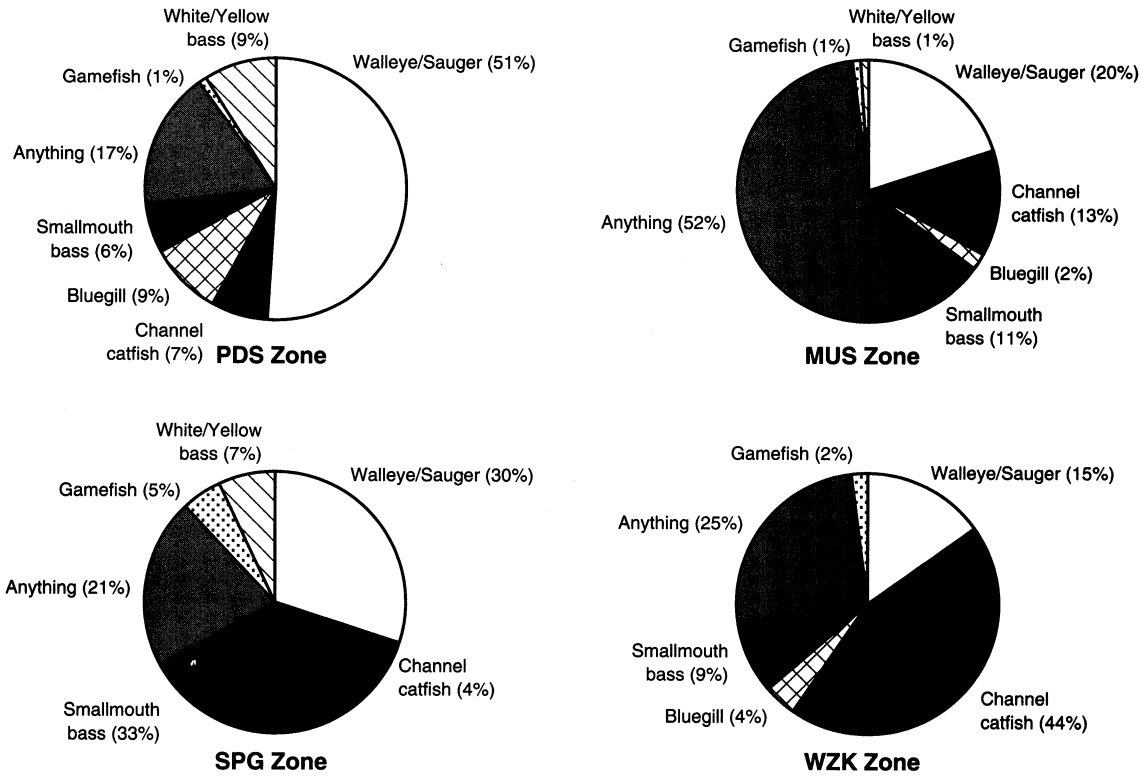

Figure 4. *Relative angling effort for various target species and groups for all 4 study zones between 11 March and 20 October 1990.*

There were strong seasonal patterns in targeted angler effort in the PDS zone (Fig. 5). More than 95% of the effort was targeted at walleye/sauger between mid-November and early May. This percentage dropped to a low of 26% during July and early August, as anglers directed their effort at a wider variety of species including channel catfish, bluegill, smallmouth bass, and white/yellow bass. Effort targeted at walleye/sauger rose again in the fall.

Catch and Harvest

Geographic Patterns. Anglers interviewed during the survey caught 47 species of fish and harvested 35. Total estimated catch and harvest were highest in the PDS zone, particularly on a per-mile or per-acre basis, followed by the WZK, MUS, and SPG zones (Table 3; more detailed data on catch and harvest are in Appendix B). From 11 March to 20 October 1990, 49% of the total catch in the LWR was in the PDS zone, 29% in the WZK zone, 12% in the MUS zone, and 10% in the SPG zone. Corresponding percentages for total harvest during this same time period were 55%, 25%, 16%, and 4%. A few species dominated catch and harvest in the LWR: bluegill, channel catfish, white/yellow bass, freshwater drum, walleye, smallmouth bass, and sauger. (We did not always separate white and yellow bass in our creel survey, because LWR anglers did not usually distinguish them. Examination of a subset of angler creels plus electrofishing catches indicated that yellow bass were uncommon.) Together, these 7 taxa made up 90% of the estimated catch and 93% of the harvest. Other taxa that made up more than 1% of total catch within one or more zones were redhorse and suckers in the SPG, MUS, and WZK zones, largemouth bass in the PDS and WZK zones, white and black crappies in the PDS zone, common carp in the PDS zone, and mooneye and goldeye in the SPG zone.

The catch and harvest of the 7 dominant taxa varied among zones (Table 3). Among-zone patterns of catch and harvest were similar, with a few exceptions. Bluegill comprised 26% of the total catch of all species and 38% of the total harvest and were among the top 3 species caught and harvested in every zone except the SPG. They made up 35% of the total catch in the PDS zone, 40% in the MUS zone, and 12% in the WZK zone. Corresponding percentages for harvest were 46%, 44%, and 24%. The catch and harvest of bluegill from the PDS zone made up about two-thirds of the total bluegill catch and harvest in the LWR. Channel catfish were among the top 3 species caught and harvested in all zones, although they comprised a smaller proportion of the total catch

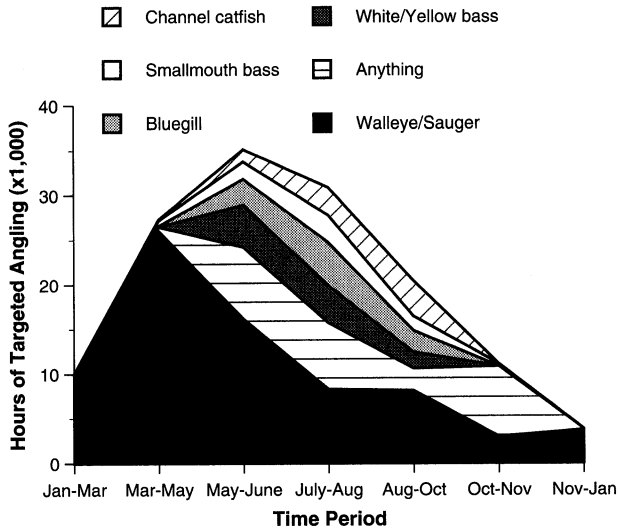

Figure 5. *Temporal distribution of angling effort for various target species and groups in the PDS zone in 1990.*

and harvest of all species in the PDS zone than in any of the 3 downstream zones. The largest catch and harvest of channel catfish were in the WZK zone. White/yellow bass and freshwater drum were among the top 5 taxa caught and harvested in all zones. Most of the white/yellow bass catch and harvest were from the PDS zone, and most of the freshwater drum catch and harvest were from the WZK zone. Catch and harvest of walleye and sauger were highest in the PDS and WZK zones. Smallmouth bass catches were similar in the PDS, SPG, and WZK zones, and much lower in the MUS zone. Harvests were higher in the WZK zone than in the other 3 zones. Generally, the percentage of catch harvested was highest

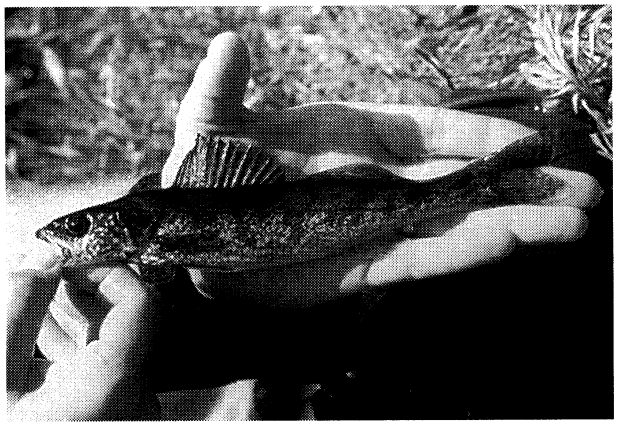

PHOTO: JOHN LYONS

Walleye are a popular catch throughout the Lower Wisconsin River, and are particularly heavily targeted by anglers from mid-November through early May in the PDS zone.

for bluegill and white/yellow bass. The MUS zone had the highest proportion of total catch harvested at 71%, and the SPG zone the lowest at 20%.

Catch and harvest per hour also varied among species and river zones (Table 4). The catch rate for all species in the LWR was 1.105 fish/hour, nearly twice the harvest rate of 0.588 fish/hour. Catch rates were highest in the PDS and WZK zones, and harvest rates were highest in the PDS and MUS zones. The harvest rate for the SPG zone was much lower than for the other 3 zones, even though the catch rate in the SPG zone was similar to that in the MUS zone. The highest individual species catch and harvest rates were for bluegill and white/yellow bass in the PDS zone, bluegill and channel catfish in the MUS zone, and channel catfish in the WZK zone. The highest catch rate in the SPG zone was for smallmouth bass, but the highest harvest rate there was for channel catfish. Bluegill catch and harvest rates were low in the SPG zone. Catch and harvest rates for channel catfish in the MUS and WZK zones were larger than in the PDS and SPG zones. The harvest rate for white/yellow bass in the PDS zone was much higher than in any other zone. Freshwater drum, walleye and sauger catch and harvest rates were relatively low in all zones, with their highest values in the WZK zone.

Seasonal Patterns. Catch and harvest varied seasonally in 1990 in the PDS zone, the only zone with data from throughout the year. Catch and harvest of all species combined peaked in summer and were lowest in the winter. Catches of bluegill, channel catfish, freshwater drum, and smallmouth bass were greatest in the late spring through early fall, peaking in July and August, and were low during the winter (Figs. 6-9). Harvest showed a similar pattern, although the peak period varied among the 4 species. Most of the catch and harvest of white/yellow bass occurred during late May and June (Fig. 10). Much lower but still substantial catch and harvest occurred into early October, with very little from mid-October through early May. Catches of walleye and sauger were highest in the winter, peaking in mid January through early March (Figs. 11-12). Walleye catch was lowest, but still substantial, in late summer and early fall, and harvest was greatest in late May and June. Sauger catch remained relatively high in spring, declined to very low levels in the summer, and rose again in the fall. Sauger harvest was greatest during the late fall and winter.

The seasonal patterns of catch and harvest in the PDS zone in 1991 were generally similar to those of 1990, although we have data only through 19 October 1991. The main exception was for white/yellow bass; during 1991 catch and harvest peaked in July and August instead of late May and June, and overall catch and harvest for the period January through October was substantially lower than in 1990.

In the downstream zones, where the survey ran only from 11 March to 20 October 1990, the catch and harvest of most species peaked in summer at the same time that angler effort peaked. The only exception to this pattern was in the WZK zone, where catch and harvest of walleye and sauger reached a maximum during late August through mid October.

Patterns Among Anglers. From 11 March to 20 October 1990, 58% of all anglers interviewed on the LWR caught at least one fish, and 32% harvested at least one fish (Table 5). There were differences in the percentage of successful anglers among both species and zones. Overall percentages for catch were highest in the SPG and WZK zones. Among the individual taxa, the highest catch percentages were for smallmouth bass in the SPG zone and channel catfish in the WZK zone. The percentage of anglers harvesting at least one fish of any species was highest in the WZK zone. Twenty-two percent of anglers in the WZK zone harvested at least one channel catfish. Over all 4 zones, harvest percentages were highest for bluegill, channel catfish, and white/yellow bass.

We also examined the distribution of harvest among anglers who kept at least one individual of a species. Because sample sizes were often small, we examined data only for the 7 dominant taxa, and we grouped together data from the SPG, MUS, and WZK zones. Individual anglers harvested up to 42 bluegills in the PDS zone and up to the legal limit of 50 in the 3 downstream zones. In both areas of the LWR, slightly more than half of those anglers who harvested bluegills kept at least 3 (Table 6). Individual anglers creeled up to the legal limit of 25 channel catfish in the PDS zone and up to 15 in the downstream zones, but in both areas, most anglers who harvested channel catfish kept only one (Table 7). One angler in the PDS zone had harvested 53 white/yellow bass (species with no bag limit) but the next highest number observed in the creel was 24 (Table 8). In the PDS Zone, most anglers who harvested white/yellow bass kept at least 2. In the downstream zones, the largest number of white/yellow bass observed in the creel was 3, and most anglers had kept only one. Although freshwater drum had no bag limit, the maximum number observed in the creel was only 9 for the PDS zone and 6 for

Table 3. *Total catch and harvest of fish from 11 Mar to 20 Oct 90, including the 7 most commonly caught and harvested taxa. A more detailed breakdown of catch and harvest is given in Appendix 2.*

	Total Catch or Harvest by Zone				
Species	**PDS**	**SPG**	**MUS**	**WZK**	**Total**
Catch					
Bluegill	55,170	835	15,380	10,724	82,109
Channel catfish	18,976	5,839	11,863	28,469	65,147
White/Yellow bass	33,696	5,539	652	4,047	43,934
Freshwater drum	11,520	2,845	2,068	17,504	33,937
Walleye	11,028	3,671	1,107	10,228	26,034
Smallmouth bass	6,924	7,140	3,063	7,649	24,776
Sauger	4,122	1,658	394	3,676	9,850
All other species	15,145	3,493	3,461	10,650	32,435
Total catch	156,581	31,020	37,988	92,947	318,532
Catch per mile	41,204	1,221	1,271	3,109	3,524
Catch per acre	175	7	5	21	18
Harvest					
Bluegill	42,992	89	11,890	9,994	64,965
Channel catfish	11,597	2,644	10,030	14,296	38,567
White/Yellow bass	27,684	1,204	627	1,413	30,928
Freshwater drum	2,308	239	1,192	6,868	10,607
Walleye	1,626	634	339	3,647	6,246
Smallmouth bass	790	892	229	1,372	3,283
Sauger	1,134	225	248	1,295	2,902
All other species	6,043	375	2,303	3,354	12,073
Total harvest	94,174	6,302	26,858	42,239	169,571
Harvest per mile	24,782	248	898	1,413	1,876
Harvest per acre	105	1	3	9	9

Table 4. *Catch and harvest per hour of fish, including the 7 most commonly caught and harvested taxa, from 11 Mar to 20 Oct 90.*

	Catch or Harvest Per Hour by Zone				
Species	**PDS**	**SPG**	**MUS**	**WZK**	**Total**
Catch rate					
Bluegill	0.416	0.024	0.354	0.139	0.285
Channel catfish	0.143	0.166	0.273	0.370	0.226
White/Yellow bass	0.254	0.158	0.015	0.053	0.152
Freshwater drum	0.087	0.081	0.048	0.227	0.118
Walleye	0.083	0.105	0.026	0.133	0.090
Smallmouth bass	0.052	0.203	0.071	0.099	0.086
Sauger	0.031	0.047	0.009	0.048	0.034
All species	1.181	0.884	0.875	1.207	1.105
Harvest rate					
Bluegill	0.324	0.003	0.274	0.130	0.225
Channel Catfish	0.087	0.075	0.231	0.186	0.134
White/Yellow Bass	0.209	0.034	0.014	0.018	0.107
Freshwater Drum	0.017	0.007	0.027	0.089	0.037
Walleye	0.012	0.018	0.008	0.047	0.022
Smallmouth Bass	0.006	0.025	0.005	0.018	0.011
Sauger	0.009	0.006	0.006	0.017	0.010
All species	0.710	0.180	0.619	0.548	0.588

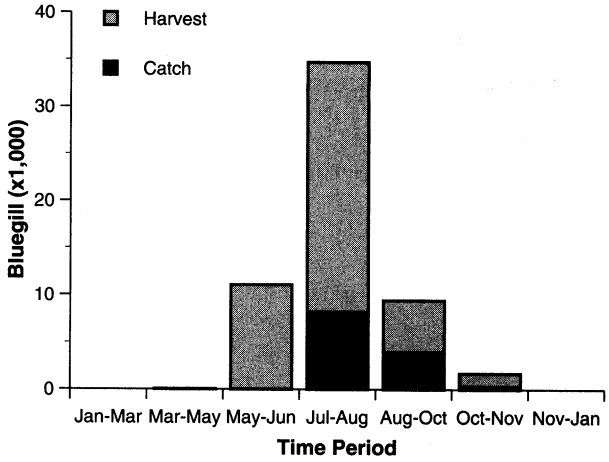

Figure 6. *Number of bluegill harvested and number caught and released, by time period, from the PDS zone in 1990.*

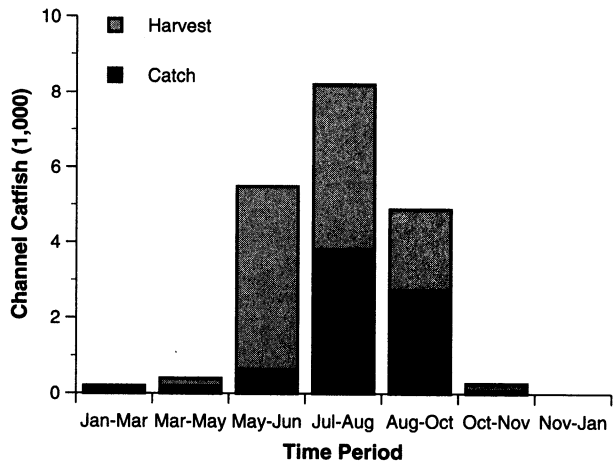

Figure 7. *Number of channel catfish harvested and number caught and released, by time period, from the PDS zone in 1990.*

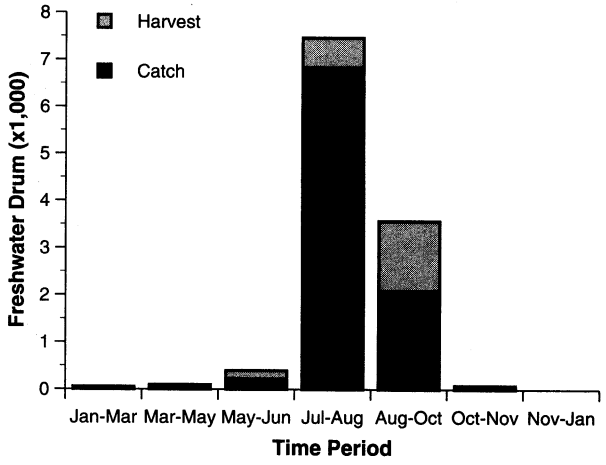

Figure 8. *Number of freshwater drum harvested and number caught and released, by time period, from the PDS zone in 1990.*

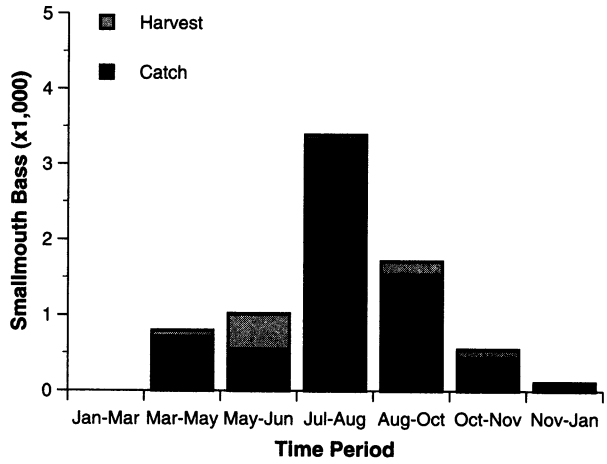

Figure 9. *Number of smallmouth bass harvested and number caught and released, by time period, from the PDS zone in 1990.*

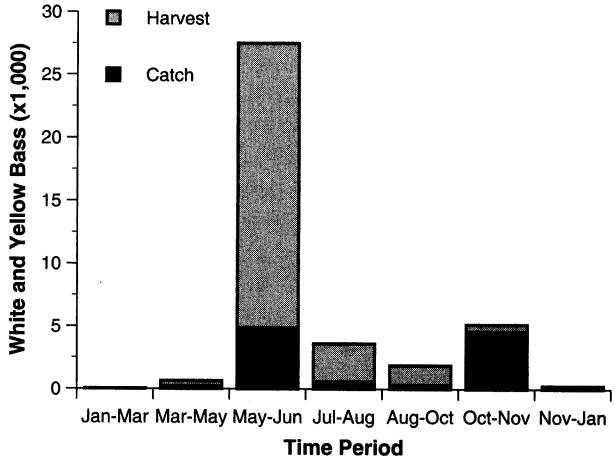

Figure 10. *Number of white/yellow bass harvested and number caught and released, by time period, from the PDS zone in 1990.*

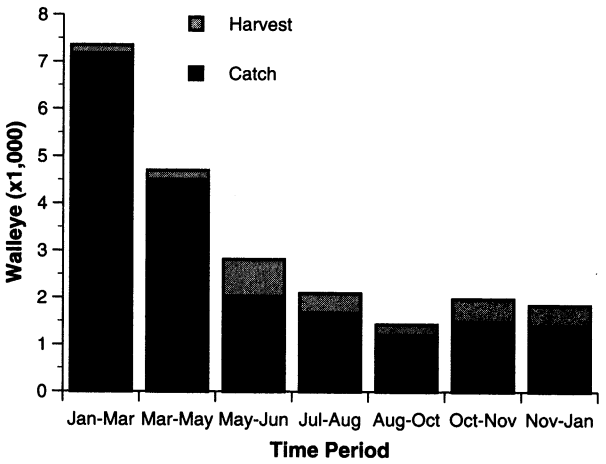

Figure 11. *Number of walleye harvested and number caught and released, by time period, from the PDS zone in 1990.*

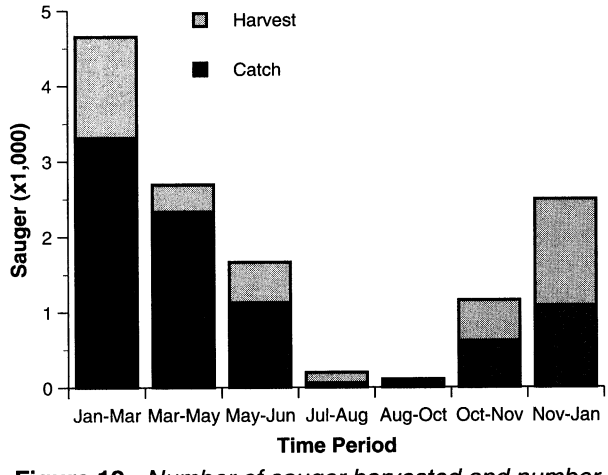

Figure 12. *Number of sauger harvested and number caught and released, by time period, from the PDS zone in 1990.*

Table 5. *Percent of successful anglers, i.e., anglers who caught or harvested at least one fish, from 11 Mar to 20 Oct 90. Standard errors for these values range from 1 to 3%.*

	Percent Successful Anglers, by Zone				
Species	**PDS**	**SPG**	**MUS**	**WZK**	**Total**
Successful catch					
Bluegill	16	6	13	8	13
Channel catfish	12	25	16	32	17
White/Yellow bass	14	17	1	5	11
Freshwater drum	10	21	8	29	14
Walleye	14	21	6	14	14
Smallmouth bass	7	41	13	15	12
Sauger	7	12	2	8	7
All species	53	72	51	73	58
Successful harvest					
Bluegill	13	2	12	5	10
Channel catfish	7	12	10	22	10
White/Yellow bass	9	7	1	3	7
Freshwater drum	3	1	4	14	5
Walleye	3	6	1	5	3
Smallmouth bass	2	6	1	3	2
Sauger	2	2	1	3	2
All species	29	28	32	44	32

the downstream zones (Table 9). Over the entire LWR, about half the anglers who harvested freshwater drum kept only one fish. For both the PDS and downstream zones, most anglers who harvested walleye, smallmouth bass, or sauger took home only one fish, (Tables 10-12). None had kept their legal limit of 5 smallmouth bass, and only a few, all but one of whom were in the PDS zone, had taken their legal limit of 5 walleye and sauger.

Size Distribution of Harvest. We examined the length distributions of harvested fish for the 7 dominant taxa, again combining results from the SPG, MUS, and WZK because of small sample sizes. For both the PDS and downstream zones, most bluegill harvested were 6 to 8 inches long (Table 13). The PDS zone had a higher percentage of harvest in the 8- to 9-inch length group than the downstream zones. The largest bluegill observed during the survey was only 9 inches. Channel catfish observed in the harvest ranged from 7 to 36 inches, with the majority ranging from 11 to 15 inches (Table 14). The size distribution of harvest in the PDS zone was similar to that in the downstream zones. The PDS zone had a wider size range of white/yellow bass harvested than the downstream zones, although this may have been an artifact of the much greater sample size in the PDS zone (Table 15). In both areas of the LWR, the majority of white/yellow bass harvested were 10 to 14 inches. A freshwater drum 35 to 36 inches long was harvested from the PDS zone, but all but one other fish observed in the creel were < 17 inches (Table 16). In the downstream zones, all freshwater drum observed were < 18 inches. For both areas, approximately three-quarters of the harvest was between 11 and 15 inches.

Of the 7 dominant taxa, only smallmouth bass and walleye were regulated by a minimum length limit for harvest. For both species, some harvest of sublegal fish occurred. For smallmouth bass, sublegal fish (<14 inches) made up about 7.5% of the observed creel in

Table 6. *Distribution of bluegill harvest among anglers who kept at least one bluegill, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	76	24.0	24.0	11	24.0	24.0
2	74	23.4	47.4	10	21.0	45.0
3	45	14.2	61.6	6	13.0	58.0
4	42	13.2	74.6	5	11.0	69.0
5	17	5.3	79.9	2	4.0	73.0
6	13	4.1	84.0	3	7.0	80.0
7	4	1.2	85.2	1	2.0	82.0
8	3	0.9	86.1	1	2.0	84.0
9	5	1.5	87.6	0	0.0	84.0
10	6	1.9	90.5	0	0.0	84.0
11	1	0.3	90.8	0	0.0	84.0
12	2	0.6	91.4	0	0.0	84.0
13	2	0.6	92.0	0	0.0	84.0
14	1	0.3	92.3	1	2.0	86.0
15	3	0.9	93.2	2	4.0	90.0
16	3	0.9	94.1	0	0.0	90.0
17	1	0.3	94.4	0	0.0	90.0
18	2	0.6	95.0	0	0.0	90.0
19	1	0.3	95.3	0	0.0	90.0
20	4	1.2	96.5	2	4.0	94.0
21	1	0.3	96.8	0	0.0	94.0
22	2	0.6	97.5	0	0.0	94.0
23	0	0.0	97.5	0	0.0	94.0
24	0	0.0	97.5	0	0.0	94.0
25	3	0.9	98.4	0	0.0	94.0
30	1	0.3	98.7	1	2.0	96.0
31	1	0.3	99.1	0	0.0	96.0
35	0	0.0	99.1	1	2.0	98.0
37	1	0.3	99.4	0	0.0	98.0
40	1	0.3	99.7	0	0.0	98.0
42	1	0.3	100.0	0	0.0	98.0
50	0	0.0	100.0	1	2.0	100.0
Total	316	100.0		47	100.0	

[a] 1990 only.

the PDS zone, but 16% of the creel in the downstream zone (Table 17). Most sublegal fish were > 13 inches. In both areas of the LWR, the majority of smallmouth bass harvested were 14 to 17 inches. For walleye, sublegal fish (<15 inches) made up a smaller percentage of the harvest—about 3% in both areas (Table 18). Smaller legal-sized walleye made up a bigger proportion of the creel in the PDS zone; 57% of the walleyes harvested in the PDS zone were 15 to 17 inches long, versus only 35% in the downstream zones. In the downstream zones, 28% of the walleyes harvested were > 20 inches long, versus only 9% in the PDS zone. There was less difference between the 2 areas for sauger, a species morphologically and ecologically similar to the walleye but not regulated by a minimum length limit. For both the PDS and downstream zones, most sauger harvested were 12 to 15 inches (Table 19). Sauger were kept as small as 9 inches in the PDS zone and 10 inches in the downstream zones, and none > 20 inches were observed from either area. In the PDS zone, 30% of the harvest was > 15 inches, versus 40% in the downstream zones.

Walleye and Sauger Exploitation. Estimated exploitation rates of walleye ≥ 15 inches and sauger ≥ 10 inches in the PDS zone were higher during 1990-91 than during 1989-90 (Table 20). Walleye exploitation was 16% during 1989-90 and 51%

Table 7. *Distribution of channel catfish harvest among anglers who kept at least one channel catfish, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	101	60.1	60.1	70	53.0	53.0
2	41	24.4	84.5	27	20.5	73.5
3	10	6.0	90.5	9	6.8	80.3
4	2	1.2	91.7	7	5.3	85.6
5	3	1.8	93.5	5	3.8	89.4
6	2	1.2	94.7	6	4.6	94.0
7	4	2.4	97.1	2	1.5	95.5
8	0	0.0	97.1	0	0.0	95.5
9	0	0.0	97.1	0	0.0	95.5
10	1	0.6	97.7	0	0.0	95.5
11	2	1.1	98.8	1	0.8	96.3
12	0	0.0	98.8	0	0.0	96.3
13	0	0.0	98.8	0	0.0	96.3
14	0	0.0	98.8	2	1.5	97.8
15	0	0.0	98.8	3	2.2	100.0
16	0	0.0	98.8	0	0.0	100.0
17	1	0.6	99.4	0	0.0	100.0
18	0	0.0	99.4	0	0.0	100.0
19	0	0.0	99.4	0	0.0	100.0
20	0	0.0	99.4	0	0.0	100.0
21	0	0.0	99.4	0	0.0	100.0
22	0	0.0	99.4	0	0.0	100.0
23	0	0.0	99.4	0	0.0	100.0
24	0	0.0	99.4	0	0.0	100.0
25	1	0.6	100.0	0	0.0	100.0
Total	168	100.0		132	100.0	

[a] 1990 only.

during 1990-91; corresponding values for sauger were 35% and 56%, respectively. The difference between years was statistically significant for walleye but not for sauger, and differences between walleye and sauger estimates in the same year were not statistically significant (*t* tests).

Modeling Regulation Changes. Our analyses of the 1990 data from the PDS zone suggested that closed seasons during the cold weather period would have had to be relatively long to substantially modify walleye or sauger harvest. Our results also indicated that because harvest of sauger was more strongly concentrated between mid-October and early May than that of walleye, season closures during this period would have more strongly affected sauger. An early March to early May closed season, which corresponded to the existing regulation on most lakes and rivers in Wisconsin in 1990, would have reduced the number of walleye harvested for the year by 7% and the number of sauger by 8%. A season closure from early January to early May would have had more substantial effects on sauger, reducing harvest by 38%, but relatively small effects on walleye, reducing harvest by only 13%. A closed season from mid-October to early May would have had a major influence on both species, reducing annual walleye harvest by 47% and sauger harvest by 83%.

During 1990 and 1991, reduced bag limits would have had a relatively small effect on annual walleye and sauger harvest from the PDS zone, although the effect on sauger would have been greater than on walleye. Most anglers who kept

Table 8. *Distribution of white/yellow bass harvest among anglers who kept at least one white bass, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	94	43.2	43.2	18	62.0	62.0
2	42	19.3	62.5	8	28.0	90.0
3	21	9.7	72.2	3	10.0	100.0
4	15	6.9	79.1	0	0.0	100.0
5	11	5.1	84.2	0	0.0	100.0
6	7	3.3	87.5	0	0.0	100.0
7	0	0.0	87.5	0	0.0	100.0
8	3	1.3	88.8	0	0.0	100.0
9	3	1.3	90.1	0	0.0	100.0
10	4	1.9	92.0	0	0.0	100.0
11	1	0.4	92.4	0	0.0	100.0
12	0	0.0	92.4	0	0.0	100.0
13	0	0.0	92.4	0	0.0	100.0
14	0	0.0	92.4	0	0.0	100.0
15	4	1.9	94.3	0	0.0	100.0
16	3	1.3	95.6	0	0.0	100.0
17	0	0.0	95.6	0	0.0	100.0
18	0	0.0	95.6	0	0.0	100.0
19	0	0.0	95.6	0	0.0	100.0
20	2	0.9	96.6	0	0.0	100.0
21	1	0.4	97.0	0	0.0	100.0
22	1	0.4	97.4	0	0.0	100.0
23	0	0.0	97.4	0	0.0	100.0
24	5	2.2	99.6	0	0.0	100.0
25	0	0.0	99.6	0	0.0	100.0
53	1	0.4	100.0	0	0.0	100.0
Total	218	100.0		29	100.0	

[a] 1990 only.

Table 9. *Distribution of freshwater drum harvest among anglers who kept at least one freshwater drum, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	54	50.5	50.5	32	50.0	50.0
2	27	25.2	75.7	21	32.7	82.7
3	14	13.1	88.8	4	6.3	89.0
4	9	8.5	97.3	5	7.8	96.8
5	0	0.0	97.3	1	1.6	98.4
6	1	0.9	98.2	1	1.6	100.0
7	0	0.0	98.2	0	0.0	100.0
8	1	0.9	99.1	0	0.0	100.0
9	1	0.9	100.0	0	0.0	100.0
10	0	0.0	100.0	0	0.0	100.0
Total	107	100.0		64	100.0	

[a] 1990 only.

Table 10. *Distribution of walleye harvest among anglers who kept at least one walleye, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	162	89.5	89.5	32	94.0	94.0
2	11	6.1	95.6	1	3.0	97.0
3	5	2.8	98.4	0	0.0	97.0
4	0	0.0	98.4	0	0.0	97.0
5	3	1.6	100.0	1	3.0	100.0
Total	181	100.0		34	100.0	

[a] 1990 only.

Table 11. *Distribution of smallmouth bass harvest among anglers who kept at least one smallmouth bass, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	43	95.5	95.5	21	72.0	72.0
2	2	4.5	100.0	7	24.0	96.0
3	0	0.0	100.0	0	0.0	96.0
4	0	0.0	100.0	1	4.0	100.0
5	0	0.0	100.0	0	0.0	100.0
Total	45	100.0		29	100.0	

[a] 1990 only.

Table 12. *Distribution of sauger harvest among anglers who kept at least one sauger, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
No. in Creel	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
1	145	69.4	69.4	17	100.0	100.0
2	32	15.4	84.8	0	0.0	100.0
3	12	5.7	90.5	0	0.0	100.0
4	7	3.3	93.8	0	0.0	100.0
5	13	6.2	100.0	0	0.0	100.0
Total	209	100.0		17	100.0	

[a] 1990 only.

Table 13. *Length frequencies of harvested bluegill, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
4-5	1	0.1	0.1	4	3.3	3.3
5-6	77	8.0	8.1	10	8.3	11.6
6-7	254	26.4	34.5	53	44.2	55.8
7-8	483	50.0	84.5	51	42.5	98.3
8-9	149	15.5	100.0	2	1.7	100.0
Total	964	100.0		120	100.0	

[a] 1990 only.

Table 14. *Length frequencies of harvested channel catfish, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
7-8	2	0.3	0.3	2	0.5	0.5
8-9	3	0.5	0.8	2	0.5	1.0
9-10	14	2.3	3.0	11	2.7	3.7
10-11	54	8.9	11.9	28	7.0	10.7
11-12	85	14.0	25.9	57	14.1	24.8
12-13	103	16.9	42.8	80	19.9	44.7
13-14	74	12.2	55.0	42	10.4	55.1
14-15	70	11.5	66.5	46	11.4	66.5
15-16	45	7.4	73.9	25	6.2	72.7
16-17	37	6.1	80.0	40	9.9	82.6
17-18	24	4.0	84.0	17	4.2	86.8
18-19	19	3.1	87.1	15	3.7	90.5
19-20	17	2.8	89.9	13	3.2	93.7
20-21	17	2.8	92.7	5	1.2	94.9
21-22	10	1.6	94.3	8	2.0	96.9
22-23	6	1.0	95.3	4	1.0	97.9
23-24	7	1.2	96.5	0	0.0	97.9
24-25	9	1.5	98.0	2	0.5	98.4
25-26	5	0.8	98.8	2	0.5	98.9
26-27	1	0.2	99.0	1	0.3	99.2
27-28	1	0.2	99.2	2	0.5	99.7
28-29	2	0.3	99.5	0	0.0	99.7
29-30	0	0.0	99.8	0	0.0	99.7
30-31	2	0.3	99.8	1	0.3	100.0
35-36	1	0.2	100.0	0	0.0	100.0
Total	608	100.0		403	100.0	

[a] 1990 only.

Table 15. *Length frequencies of harvested white/yellow bass, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
4-5	4	0.5	0.5	0	0.0	0.0
5-6	8	1.0	1.5	0	0.0	0.0
6-7	7	0.9	2.4	0	0.0	0.0
7-8	3	0.4	2.8	0	0.0	0.0
8-9	23	3.0	5.8	0	0.0	0.0
9-10	75	9.7	15.5	6	9.5	9.5
10-11	151	19.6	35.1	16	25.4	34.9
11-12	140	18.1	53.2	19	30.1	65.0
12-13	128	16.6	69.9	12	19.1	84.1
13-14	101	13.1	83.0	6	9.5	93.6
14-15	76	9.8	92.8	2	3.2	96.8
15-16	36	4.7	97.5	1	1.6	98.4
16-17	11	1.4	98.9	1	1.6	100.0
17-18	6	0.7	99.6	0	0.0	100.0
18-19	3	0.4	100.0	0	0.0	100.0
19-20	0	0.0	100.0	0	0.0	100.0
Total	772	100.0		63	100.0	

[a] 1990 only.

Table 16. *Length frequencies of harvested freshwater drum, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
5-6	0	0.0	0.0	2	1.0	1.0
6-7	0	0.0	0.0	1	0.5	1.5
7-8	2	0.6	0.6	3	1.6	3.1
8-9	3	1.0	1.6	3	1.6	4.7
9-10	13	4.1	5.7	15	7.8	12.5
10-11	30	9.5	15.2	27	14.0	26.5
11-12	58	18.3	33.5	35	18.1	44.6
12-13	56	17.7	51.2	39	20.2	64.8
13-14	74	23.3	74.5	22	11.4	76.2
14-15	55	17.4	91.9	23	11.8	88.0
15-16	20	6.2	98.1	11	5.7	93.7
16-17	4	1.3	99.4	8	4.2	97.9
17-18	0	0.0	99.4	4	2.1	100.0
18-19	0	0.0	99.4	0	0.0	100.0
19-20	0	0.0	99.4	0	0.0	100.0
20-21	1	0.3	99.7	0	0.0	100.0
35-36	1	0.3	100.0	0	0.0	100.0
Total	317	100.0		193	100.0	

[a]1990 only.

Table 17. *Length frequencies of harvested smallmouth bass, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
10-11	1	1.7	1.7	0	0.0	0.0
11-12	1	1.7	3.4	2	4.0	4.0
12-13	0	0.0	3.4	0	0.0	0.0
13-14	3	4.3	7.7	6	12.0	16.0
14-15	17	28.0	35.7	20	40.0	56.0
15-16	24	39.3	75.0	10	20.0	76.0
16-17	10	16.5	91.5	6	12.0	88.0
17-18	2	3.4	94.9	3	6.0	94.0
18-19	2	3.4	98.3	2	4.0	98.0
19-20	1	1.7	100.0	0	0.0	98.0
20-21	0	0.0	100.0	1	2.0	100.0
Total	61	100.0		50	100.0	

[a]1990 only.

Table 18. *Length frequencies of harvested walleye, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
13-14	3	0.9	0.9	1	1.7	1.7
14-15	7	2.1	3.0	1	1.7	3.4
15-16	98	29.7	32.7	7	11.7	15.1
16-17	91	27.6	60.3	14	23.3	38.4
17-18	54	16.4	76.7	8	13.3	51.7
18-19	28	8.5	85.2	7	11.7	63.4
19-20	19	5.8	91.0	5	8.3	71.7
20-21	9	2.7	93.7	6	10.0	81.7
21-22	8	2.4	96.1	1	1.7	83.4
22-23	4	1.2	97.3	3	5.0	88.4
23-24	3	0.9	98.2	5	8.2	96.6
24-25	5	1.5	99.7	0	0.0	96.6
25-26	1	0.3	100.0	1	1.7	98.3
26-27	0	0.0	100.0	0	0.0	98.3
27-28	0	0.0	100.0	1	1.7	100.0
Total	330	100.0		60	100.0	

[a] 1990 only.

Table 19. *Length frequencies of harvested sauger, 1990-91.*

	PDS Zone			SPG, MUS, WZK Zones[a]		
Inch Class	No. of Anglers	% of Anglers	Cumulative %	No. of Anglers	% of Anglers	Cumulative %
9-10	4	1.0	1.0	0	0.0	0.0
10-11	12	3.1	4.1	1	3.3	3.3
11-12	15	3.9	8.0	1	3.3	6.6
12-13	44	11.5	19.5	4	13.3	19.9
13-14	79	20.6	40.1	7	23.3	43.2
14-15	114	29.8	69.9	5	16.9	60.1
15-16	71	18.5	88.4	7	23.3	83.4
16-17	29	7.6	96.0	3	10.0	93.4
17-18	10	2.7	98.7	1	3.3	96.7
18-19	1	0.3	99.0	0	0.0	96.7
19-20	4	1.0	100.0	1	3.3	100.0
Total	383	100.0		30	100.0	

[a] 1990 only.

Table 20. *Angler exploitation of walleye ≥15 inches and sauger ≥10 inches in the PDS zone during the period fall through spring.*

	Oct 89-May 90		Oct 90-May 91	
	Walleye	Sauger	Walleye	Sauger
Number of fish tagged in the fall	136	415	524	418
Estimated number of tagged fish harvested:				
Oct-Jan	12	78	145	123
Jan-May	10	69	123	109
Total	22	147	268	232
Estimated % Exploitation	16.1	35.4	51.1	55.5
Standard error (%)	15.8	18.7	12.9	16.3

walleye or sauger creeled only one fish, and stricter daily bag limits would have had no influence on their harvest. Even under a daily bag limit of one fish, walleye harvest would have been reduced only 15% and sauger harvest only 38%.

Changes in minimum length limits would have had the most substantial effect on annual walleye and sauger harvest in the PDS zone during 1990 and 1991. Imposition of a 15-inch limit on sauger would have reduced harvest by 69%, whereas a 16-inch limit would have reduced harvest by 88%. A 20-inch limit would have essentially eliminated sauger harvest. Conversely, a minimum length limit of 12 inches would have had little effect, reducing harvest by only 7%. For walleye, raising the minimum length limit from 15 to 16 inches would have reduced harvest by 33%. A 17-inch limit would have reduced harvest by 60%, whereas a 20-inch limit would have reduced harvest by 91%. A 26-inch limit would have essentially eliminated walleye harvest.

Discussion

Implications of Biases in the Creel Survey

In general, it was difficult to correct for the biases that we identified—private access sites, shore angling, night angling, and movement between zones—and to determine their relative magnitude. The only bias that may have had a simple solution was movement between zones, which could have been corrected either by asking boaters where they began their trip (which we did not do) or by basing estimates on ending trips only. The problems with this second solution were that it would not use all of the information available on effort, and it would increase the underestimation problem associated with night angling. Moreover, even if the bias in effort could be corrected, we would still lack relative catch rates for each zone for those boaters who moved between zones. For all except the MUS zone, estimates based on ending trips were only about 70% as large as those based on cumulative counts; for the MUS zone the value was 106%. The difference in the estimates was due to the consistently larger count of starting rather than completing trips in all zones except MUS, and reflected the inclusion of some night angling effort in the estimates based on cumulative counts. For the period during which the SPG zone was surveyed, 11 March to 20 October 1990, the ratio of the estimate based on completing trips to that based on cumulative counts was 0.7 for the SPG zone and 0.8 for the PDS zone. If the difference in this ratio represented the difference due to over- or under-estimating the proportion of boat trips that were angling, then this bias in total angling effort was on the order of only 5 to 10%. Because this bias was relatively small and existed only in the summer, and because all other biases were negative, we used the larger effort and harvest estimates based on cumulative counts. While these were still underestimates, they should have been closer to the actual values than the ending trip estimates.

Angling Effort

Fishing pressure varied greatly among the 4 study zones of the LWR. Angling effort in the PDS zone in 1990 and 1991 was high enough to qualify this area as one of the most heavily fished in the state on a per-acre basis (Table 21). Conversely, the 3 downstream study zones had low fishing pressure relative to other waters in the region, although the SPG zone received substantial boat use by nonanglers (Table 2).

The high angler effort in the PDS zone was probably due to several factors. First, anglers were attracted by the large concentrations of fish in the zone. These concentrations occurred because upstream-moving fish "piled up" below the dam, and because the tailwater area had unique, deep-water habitat. Moreover, some fish passed through or over the dam into the zone from upstream Lake Wisconsin. Second, the PDS zone was closest to large population centers, and was served by major highways. Most anglers in the PDS zone came from adjacent Sauk and Dane Counties, but nearly a quarter came from Illinois. A much lower percentage of out-of-state anglers fished the downstream zones. Third, there were many access sites in the PDS zone, so that even if one was crowded, others were available. Finally, the PDS zone contained 2 sizeable towns that contributed local anglers to the fishery and attracted nonlocal anglers with restaurants, motels, and bait stores.

These same factors, but from the opposite perspective, probably accounted for the relatively low angling effort in the 3 downstream zones. In these areas, concentrations of fish were less obvious or accessible, major population centers and highways were further away, and there were few nearby towns. Angler access was generally more limited and difficult.

The 4 study zones also differed greatly in the kinds of anglers that used them (Fig. 4). In the PDS zone, where there was substantial effort all

Table 21. *Angler effort estimates for large lakes and rivers in or near southern Wisconsin.*

Water body	Survey Dates	Angler Hours		Reference
		Total	Per Acre	
Lake Mendota	7/81 - 6/82	151,591	15.4	DNR, unpublished data
Lake Mendota	1/87 - 10/87	289,736	29.4	Johnson and Staggs 1992
Lake Mendota	1/88 - 10/88	273,269	27.8	Johnson and Staggs 1992
Lake Mendota	1/89 - 10/89	552,689	56.2	Johnson and Staggs 1992
Lake Waubesa	7/82 - 6/83	174,654	84.0	DNR, unpublished data
Fox Lake	5/74 - 4/75	704,332	268.0	Congdon 1988
Pool 5A, Mississippi River	9/87 - 9/88	153,680	25.0	Langrehr and Benjamin 1989
Rock River, Ill.	6/88 - 5/89	322,021	29.5	Heidinger et al. 1989
Lower Wisconsin River:				
PDS zone	3/90 - 10/90	132,632	147.4	This study
SPG zone	3/90 - 10/90	35,111	7.5	This study
MUS zone	3/90 - 10/90	43,398	5.4	This study
WZK zone	3/90 - 10/90	77,026	17.1	This study
All 4 zones	3/90 - 10/90	288,167	15.9	This study
PDS zone	1/90 - 1/91	154,496	170.6	This study
PDS zone	1/90 - 10/90	142,637	158.5	This study
PDS zone	1/91 - 10/91	131,846	146.5	This study

year, walleye/sauger anglers dominated from mid October through early May (Fig. 5). As effort increased in the summer, anglers in the PDS zone targeted a more diverse group of species, including bluegill, white/yellow bass, catfish, and smallmouth bass as well as walleye/sauger. Most anglers in the SPG zone targeted smallmouth bass or walleye/sauger, and kept the smallest proportion—about 20%—of the fish they caught. In contrast, approximately 50% of the anglers in the MUS zone fished for "anything," and the rest targeted a variety of species. Anglers in the MUS zone also kept the highest proportion—71%—of the fish that they caught, including many nongame species. Anglers in the WZK zone targeted mainly catfish, "anything," walleye/sauger, and smallmouth bass.

Catch and Harvest

The LWR supported a diverse fishery, with a large number of fish species caught and harvested, and consequently provided a wide range of angling opportunities. However, population data are lacking for many of the species in the fishery. During the last 10 years, the Fisheries Management and Fish Research programs of the DNR have collected information about the more common and popular large gamefish in the river: walleye, sauger, channel catfish, flathead catfish, and to a lesser extent, smallmouth bass, largemouth bass, northern pike, and tiger muskellunge. While studies of these species were certainly needed, the creel survey indicated that studies on additional species would also be valuable. In particular, "panfish" species, especially white/yellow bass and bluegill, deserve more attention. Panfish were the most commonly caught and harvested group of fish in the PDS zone, and made up a major fraction of the catch and harvest in the MUS and WZK zones (Table 3). Nearly one-fifth of angling effort in the PDS zone was specifically targeted towards bluegill and white/yellow bass. The DNR has few data on the population dynamics of panfish in the LWR, and at this point cannot determine whether any panfish species are being overexploited. Efforts to manage the fishery in the LWR would be greatly enhanced by more information about panfish distribution, relative abundance, recruitment, movement patterns, size and age structure, growth rates, and relationships with other species.

Other fishes that were important in the LWR fishery were the nongame or "rough" fishes, especially freshwater drum, redhorse and suckers, common carp, and mooneye and goldeye. Although almost no anglers specifically targeted nongame species in their fishing, in some zones, nongame species made up more than 10% of the catch or harvest (Appendix B). Despite the prominent role of nongame fish in the LWR fishery, the DNR has little population information about them, and cannot determine whether any are being

overexploited. As is the case for panfish species, additional data on population parameters for the more common nongame fishes would help improve management of the overall LWR fishery.

Although more needs to be known about many species in the LWR, this creel survey has generated a data set that will be very useful in fishery management. Now that detailed data on angler effort, catch, and harvest are available from 1990 and 1991 for comparison, future surveys can be used to detect trends in the fishery. With careful interpretation, catch and harvest data can provide insight into the distribution, relative abundance, and size structure of many species. Harvest data can also be used to model potential regulation changes, in much the same manner as we did for walleye and sauger. Angler effort information can be used to help plan access site development, and to design strategies to avoid or minimize user conflicts on the LWR.

The Walleye/Sauger Fishery in the PDS Zone

One of the most prominent features of the LWR fishery in 1990 and 1991 was the seasonal fishery for walleye and sauger in the PDS zone. Much of the walleye and sauger catch and harvest in the PDS zone occurred between mid-October and early May, when large numbers of walleye were concentrated there. Tagging studies have shown that many walleye and sauger spend the summer in the SPG or MUS zones and then migrate to the PDS zone for the colder months (D. Fago and T. Pellett, DNR, unpublished data). Relatively few walleye or sauger migrate between the PDS zone and the WZK zone or the Mississippi River. The PDS zone apparently provides more extensive and possibly better quality winter habitat than the SPG and MUS zones, and also serves as an important staging area prior to spring spawning. During or following spawning, many walleye and sauger disperse back downstream from the PDS zone into the SPG and MUS zones. Thus, from fall through early spring, substantial proportions of the total walleye and sauger populations in the upper portion of the LWR are likely to be found within the 3.8 miles of the PDS zone, but during the summer these populations are spread out over more than 60 miles of the LWR.

In a sense, the SPG and MUS zones act as refuges for walleye and sauger, providing a region where both fishing pressure and the probability of harvest are relatively low. During the summer, the SPG and MUS zones probably hold a substantial fraction of the walleye and sauger that fuels the late fall to early spring fishery in the PDS zone, yet walleye and sauger catch and harvest in these 2 zones were limited in 1990. If increased harvest of walleye and sauger were to occur during the summer in the SPG and MUS zones, it might lead to a decrease in the number of fish available for the late fall to early spring fishery in the PDS zone.

Angler exploitation rates for walleye $\geq$ 15 inches and sauger $\geq$ 10 inches in the PDS may have been too high during 1990-91. The DNR has recommended that annual exploitation of walleye adults not exceed 35% in northern Wisconsin lakes (Hansen 1989). Although size at maturity is unknown for LWR walleye and sauger, data on size and age at maturity from other Wisconsin waters (Becker 1983, Wis. Dep. Nat. Resour. 1990) coupled with age and growth data from the LWR (J. Lyons, DNR, unpublished data) suggest that in the LWR, most adult walleyes were > 15 inches and most adult sauger were > 10 inches. Thus, the 35% guideline can probably be applied directly to our angler exploitation data. Sauger exploitation was at the 35% limit for the period mid-October 1989 through early May 1990, and both walleye and sauger exploitation exceeded this limit between mid-October 1990 and early May 1991 (Table 20). Moreover, our exploitation estimates may have been underestimates because of tag loss, and they were made when many walleye and sauger from the SPG and MUS zones were concentrated in the PDS zone.

Data from population surveys are required to determine if angler exploitation during 1990-91 negatively affected the walleye and sauger populations in the LWR. If these data indicate a declining trend in abundance or size structure, then stricter regulations should be implemented to reduce angler harvest. Of the 3 regulation changes that we examined, increased minimum size limits may be the most effective. For example, our modeling suggests that imposition of a 15-inch size limit for sauger and an increase in the walleye size limit to 17 inches would decrease the number of fish harvested annually by about 60% for each species. A long closed season would be needed to achieve a similar decline in harvest, and reduced bag limits, short of a no-kill regulation, would be unable to reduce harvest by this much.

We must temper any recommended regulation change with the caveat that our modeling was based on walleye and sauger populations that may have been in transition between a fishery with no size limits and a fishery with a 15-inch walleye size limit. The creel survey may have taken place too soon after the regulation change for potential walleye population changes in response to the size limit. Also, although sauger were not protected by a size limit, their population in the LWR could also be affected by the walleye regulation. The imposition of the walleye size limit in 1990 could have shifted harvest from walleye to sauger, thus possibly leading to a shift in the sauger population that our surveys were unable to detect. Circumstantial evidence for increased harvest pressure on sauger included the high proportion of sauger < 15 inches that were harvested (Table 19), and a higher ratio of harvest to catch for sauger than for walleye (Table 3). If the walleye and sauger populations in 1990 and 1991 were not representative of those that would exist after several years of a 15-inch walleye size limit, then our modeling predictions might not apply to these future populations.

Management Recommendations

Based on the results of the creel survey and our knowledge of the fishes and fishery of the LWR, we make the following recommendations:

1. Conduct another creel survey of the entire LWR, or at least the PDS zone, within the next 5 years to identify trends in the fishery.
2. Initiate studies of bluegill, white/yellow bass, and freshwater drum to learn more about their population dynamics and relationships with other species.
3. If ongoing population surveys indicate a declining trend in walleye or sauger abundance or size structure, implement more restrictive size limits to reduce angler harvest.

Appendixes

Appendix A. Table A.1. *Common and scientific names of fish species mentioned in this report. Species are listed in taxonomic order by family and alphabetically, based on scientific name, within family.*

Common name	Scientific name
Sturgeon Family	**Acipenseridae**
Lake sturgeon	*Acipenser fulvescens*
Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Paddlefish Family	**Polyodontidae**
Paddlefish	*Polyodon spathula*
Gar Family	**Lepisosteidae**
Longnose gar	*Lepisosteus osseus*
Shortnose gar	*Lepisosteus platostomus*
Bowfin Family	**Amiidae**
Bowfin	*Amia calva*
Mooneye Family	**Hiodontidae**
Goldeye	*Hiodon alosoides*
Mooneye	*Hiodon tergisus*
Eel Family	**Anguillidae**
American eel	*Anguilla rostrata*
Herring Family	**Clupeidae**
Gizzard shad	*Dorosoma cepedianum*
Minnow Family	**Cyprinidae**
Common carp	*Cyprinus carpio*
Sucker Family	**Catostomidae**
River carpsucker	*Carpiodes carpio*
Quillback	*Carpiodes cyprinus*
Highfin carpsucker	*Carpiodes velifer*
White sucker	*Catostomus commersoni*
Blue sucker	*Cycleptus elongatus*
Smallmouth buffalo	*Ictiobus bubalus*
Bigmouth buffalo	*Ictiobus cyprinellus*
Black buffalo	*Ictiobus niger*
Silver redhorse	*Moxostoma anisurum*
Golden redhorse	*Moxostoma erythrurum*
Shorthead redhorse	*Moxostoma macrolepidotum*
Catfish Family	**Ictaluridae**
Yellow bullhead	*Ameiurus natalis*
Black bullhead	*Ameiurus melas*
Brown bullhead	*Ameiurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictis olivaris*
Pike Family	**Esocidae**
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Tiger muskellunge	*E. lucius* x *E. masquinongy*
Trout Family	**Salmonidae**
Brown trout	*Salmo trutta*
Cod Family	**Gadidae**
Burbot	*Lota lota*
Killifish Family	**Cyprinodontidae**
Starhead topminnow	*Fundulus dispar*
Temperate Bass Family	**Percichthyidae**
White bass	*Morone chrysops*
Yellow bass	*Morone mississippiensis*
Sunfish Family	**Centrarchidae**
Rock bass	*Ambloplites rupestris*
Pumpkinseed	*Lepomis gibbosus*
Warmouth	*Lepomis gulosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieu*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Perch Family	**Percidae**
Yellow perch	*Perca flavescens*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*
Saugeye	*S. vitreum* x *S. canadense*
Drum Family	**Sciaenidae**
Freshwater drum	*Aplodinotus grunniens*

Appendix B. Table B.1. *Estimated angler catch and harvest of fish species and species groups from the PDS zone between 11 Mar and 20 Oct 90. In this and subsequent tables: "SE" is standard error.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	40	25	0.000	0	0	0.000	0.0
Shovelnose sturgeon	147	75	0.001	0	0	0.000	0.0
Unspecified sturgeon	321	121	0.002	0	0	0.000	0.0
Paddlefish	308	130	0.002	0	0	0.000	0.0
Nongame predators[a]	184	114	0.001	0	0	0.000	0.0
Mooneye and goldeye	81	54	0.001	0	0	0.000	0.0
Common carp	1,530	662	0.012	278	114	0.002	18.2
Carpsuckers[a]	383	214	0.003	169	84	0.001	44.0
Buffalos[a]	948	454	0.007	176	110	0.001	18.6
Redhorse and Suckers[a]	598	195	0.005	187	85	0.001	31.2
Bullheads[a]	16	16	0.000	0	0	0.001	0.0
Channel catfish	18,976	4,655	0.143	11,597	3,395	0.087	61.1
Flathead catfish	42	21	0.000	32	19	0.000	76.5
Northern pike	159	81	0.001	28	28	0.000	17.5
Muskellunge[a]	64	38	0.000	0	0	0.000	0.0
White and Yellow bass	33,696	9,480	0.254	27,684	9,023	0.209	82.2
Misc. panfish[a]	519	179	0.004	95	56	0.001	18.4
Bluegill	55,170	13,600	0.416	42,992	10,517	0.324	77.9
Smallmouth bass	6,924	1,817	0.052	790	270	0.006	11.4
Largemouth bass	2,159	819	0.016	206	109	0.002	9.5
Crappies[a]	5,953	2,524	0.045	4,745	1,847	0.036	79.7
Sauger	4,122	880	0.031	1,134	300	0.009	27.5
Walleye	11,028	1,917	0.083	1,626	397	0.012	14.7
Saugeye	0	0	0.000	0	0	0.000	–
Freshwater drum	11,520	2,505	0.087	2,308	561	0.017	20.0
Other species	1,693	1,255	0.013	127	54	0.001	7.5
Total	156,581	17,887	1.181	94,174	14,410	0.710	60.1

[a] "Non game predators" includes longnose and shortnose gar, bowfin, American eel, and burbot; "Carpsuckers" includes river carpsucker, quillback, and highfin carpsucker; "Buffalos" includes smallmouth, bigmouth, and black buffalo; "Redhorse and Suckers" includes white and blue sucker, and silver, golden, and shorthead redhorse; "Bullheads" includes yellow, black, and brown bullhead; "Muskellunge" includes muskellunge and tiger muskellunge; "Crappies" includes white and black crappie; "Miscellaneous panfish" includes rock bass, pumpkinseed, warmouth, and yellow perch; and "Other Species" includes gizzard shad, unspecified cyprinids, and brown trout.

Table B.2. *Estimated angler catch and harvest of fish species and species groups from the SPG zone between 11 Mar and 20 Oct 90.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	0	0	0.000	0	0	0.000	–
Shovelnose sturgeon	0	0	0.001	0	0	0.000	–
Unspecified sturgeon	0	0	0.000	0	0	0.000	–
Paddlefish	0	0	0.000	0	0	0.000	–
Nongame predators	64	44	0.002	0	0	0.000	0.0
Mooneye and goldeye	1,263	409	0.036	99	99	0.003	7.8
Common carp	40	43	0.001	0	0	0.000	0.0
Carpsuckers	0	0	0.000	0	0	0.000	–
Buffalos	0	0	0.000	0	0	0.000	–
Redhorse and suckers	628	253	0.018	0	0	0.000	0.0
Bullheads	0	0	0.000	0	0	0.000	–
Channel catfish	5,839	1,981	0.166	2,644	1,242	0.075	45.3
Flathead catfish	128	128	0.004	128	128	0.004	100.0
Northern pike	190	101	0.005	0	0	0.000	0.0
Muskellunge	0	0	0.000	0	0	0.000	–
White and yellow bass	5,539	2,305	0.158	1,204	494	0.034	21.7
Misc. panfish	782	231	0.022	66	66	0.002	8.4
Bluegill	835	266	0.024	89	58	0.003	10.6
Smallmouth bass	7,140	1,458	0.203	892	281	0.025	12.5
Largemouth bass	349	161	0.010	33	33	0.001	9.4
Crappies	49	49	0.001	49	49	0.001	100.0
Sauger	1,658	572	0.047	225	141	0.006	13.6
Walleye	3,671	1,018	0.105	634	234	0.018	17.3
Saugeye	0	0	0.000	0	0	0.000	–
Freshwater drum	2,845	642	0.081	239	230	0.007	8.4
Other species	0	0	0.000	0	0	0.000	–
Total	31,020	3,682	0.884	6,302	1,424	0.180	20.3

Table B.3. *Estimated angler catch and harvest of fish species and species groups from the MUS zone between 11 Mar and 20 Oct 90.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	86	69	0.002	0	0	0.000	0.0
Shovelnose sturgeon	126	63	0.003	95	95	0.002	75.6
Unspecified sturgeon	129	60	0.003	41	39	0.001	31.4
Paddlefish	0	0	0.000	0	0	0.000	–
Nongame predators	197	125	0.005	141	118	0.003	71.4
Mooneye and goldeye	358	137	0.008	224	88	0.005	62.4
Common carp	64	38	0.001	42	31	0.001	65.5
Carpsuckers	116	77	0.003	94	73	0.002	81.0
Buffalos	25	25	0.001	0	0	0.000	0.0
Redhorse and suckers	1,913	474	0.044	1,428	419	0.033	74.7
Bullheads	0	0	0.000	0	0	0.000	–
Channel catfish	11,863	3,739	0.273	10,030	3,480	0.231	84.6
Flathead catfish	0	0	0.000	0	0	0.000	–
Northern pike	91	54	0.002	60	45	0.001	66.1
Muskellunge	0	0	0.000	0	0	0.000	–
White and yellow bass	652	334	0.015	627	332	0.014	96.1
Misc. panfish	133	70	0.003	64	49	0.001	47.8
Bluegill	15,380	4,176	0.354	11,890	3,614	0.274	77.3
Smallmouth bass	3,063	699	0.071	229	104	0.005	7.5
Largemouth bass	121	78	0.003	53	39	0.001	44.2
Crappies	41	40	0.001	0	0	0.000	0.0
Sauger	394	254	0.009	248	148	0.006	62.9
Walleye	1,107	310	0.026	339	150	0.008	30.6
Saugeye	0	0	0.000	0	0	0.000	–
Freshwater drum	2,068	443	0.048	1,193	381	0.027	57.7
Other species	63	47	0.001	63	47	0.001	100.0
Total	37,988	5,716	0.875	26,858	5,069	0.619	70.7

Table B.4. *Estimated angler catch and harvest of fish species and species groups from the WZK zone between 11 Mar and 20 Oct 90.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	18	18	0.000	0	0	0.000	0.0
Shovelnose sturgeon	320	167	0.004	320	167	0.004	100.0
Unspecified sturgeon	98	83	0.001	0	0	0.000	0.0
Paddlefish	0	0	0.000	0	0	0.000	–
Nongame predators	238	99	0.003	18	18	0.000	7.5
Mooneye and goldeye	37	38	0.000	0	0	0.000	0.0
Common carp	384	136	0.005	226	107	0.003	59.0
Carpsuckers	692	316	0.009	80	80	0.001	11.5
Buffalos	233	83	0.003	126	57	0.002	54.2
Redhorse and suckers	5,439	1,411	0.071	1,375	459	0.018	25.3
Bullheads	103	63	0.001	66	51	0.001	64.2
Channel catfish	28,469	5,888	0.370	14,296	2,651	0.186	50.2
Flathead catfish	258	102	0.003	258	102	0.003	100.0
Northern pike	197	122	0.003	18	18	0.000	9.1
Muskellunge	0	0	0.000	0	0	0.000	–
White and yellow bass	4,047	1,479	0.053	1,413	619	0.018	34.9
Misc. panfish	968	588	0.013	849	585	0.011	87.8
Bluegill	10,724	5,503	0.139	9,994	5,484	0.130	93.2
Smallmouth bass	7,649	1,595	0.099	1,372	448	0.018	17.9
Largemouth bass	1,218	405	0.016	18	18	0.000	1.5
Crappies	412	254	0.005	0	0	0.000	0.0
Sauger	3,676	910	0.048	1,295	457	0.017	35.2
Walleye	10,228	2,669	0.133	3,647	1,319	0.047	35.7
Saugeye	0	0	0.000	0	0	0.000	–
Freshwater drum	17,504	2,995	0.227	6,868	1,338	0.089	39.2
Other species	36	37	0.000	0	0	0.000	0.0
Total	92,947	9,454	1.207	42,239	6,484	0.548	45.4

Table B.5. *Estimated angler catch and harvest of fish species and species groups from the PDS zone between 14 Jan 90 and 12 Jan 91.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	82	43	0.001	0	0	0.000	0.0
Shovelnose sturgeon	201	80	0.001	0	0	0.000	0.0
Unspecified sturgeon	346	123	0.002	0	0	0.000	0.0
Paddlefish	405	137	0.003	0	0	0.000	0.0
Nongame predators	184	114	0.001	0	0	0.000	0.0
Mooneye and goldeye	81	54	0.001	0	0	0.000	0.0
Common carp	1,718	677	0.011	278	114	0.002	16.2
Carpsuckers	495	236	0.003	267	129	0.002	53.9
Buffalos	1,255	519	0.008	482	274	0.003	38.5
Redhorse and suckers	680	198	0.004	187	85	0.001	27.4
Bullheads	16	16	0.000	0	0	0.000	0.0
Channel catfish	19,428	4,658	0.127	11,783	3,396	0.077	60.7
Flathead catfish	69	35	0.000	32	19	0.000	46.4
Northern pike	177	83	0.001	28	28	0.000	15.7
Muskellunge	83	41	0.001	0	0	0.000	0.0
White and yellow bass	34,605	9,488	0.225	28,363	9,030	0.185	82.0
Misc. panfish	662	199	0.004	190	90	0.001	28.7
Bluegill	56,868	13,634	0.370	44,382	10,557	0.289	78.0
Smallmouth bass	7,589	1,831	0.049	918	277	0.006	12.1
Largemouth bass	2,281	825	0.015	206	109	0.001	9.0
Crappies	6,746	2,561	0.044	5,249	1,876	0.034	77.8
Sauger	12,425	1,908	0.081	4,429	748	0.029	35.6
Walleye	22,193	2,961	0.145	2,710	450	0.018	12.2
Saugeye	247	120	0.002	247	120	0.002	100.0
Freshwater drum	11,654	2,505	0.076	2,344	562	0.015	20.1
Other species	1,723	1,255	0.011	127	54	0.001	7.4
Total	182,212	18,149	1.187	102,222	14,468	0.666	56.1

Table B.6. *Estimated angler catch and harvest of fish species and species groups from the PDS zone between 14 Jan and 20 Oct 90.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	40	25	0.000	0	0	0.000	0.0
Shovelnose sturgeon	201	80	0.001	0	0	0.000	0.0
Unspecified sturgeon	334	122	0.002	0	0	0.000	0.0
Paddlefish	381	134	0.003	0	0	0.000	0.0
Nongame predators	184	114	0.001	0	0	0.000	0.0
Mooneye and goldeye	81	54	0.001	0	0	0.000	0.0
Common carp	1,680	676	0.012	278	114	0.002	16.5
Carpsuckers	481	235	0.003	267	129	0.002	55.4
Buffalos	1,194	516	0.008	421	269	0.003	35.3
Redhorse and suckers	598	195	0.004	187	85	0.001	31.2
Bullheads	16	16	0.000	0	0	0.000	0.0
Channel catfish	19,166	4,656	0.134	11,610	3,395	0.081	60.6
Flathead catfish	69	35	0.000	32	19	0.000	46.4
Northern pike	159	81	0.001	28	28	0.000	17.5
Muskellunge	83	41	0.001	0	0	0.000	0.0
White and yellow bass	33,736	9,480	0.237	27,711	9,023	0.194	82.1
Misc. panfish	519	179	0.004	95	56	0.001	18.4
Bluegill	55,170	13,600	0.387	42,992	10,517	0.301	77.9
Smallmouth bass	6,924	1,817	0.049	790	270	0.006	11.4
Largemouth bass	2,257	825	0.016	206	109	0.001	9.1
Crappies	5,953	2,524	0.042	4,745	1,847	0.033	79.7
Sauger	8,778	1,728	0.062	2,478	511	0.017	28.2
Walleye	18,377	2,897	0.129	1,795	414	0.013	9.8
Saugeye	247	120	0.002	247	127	0.002	100.0
Freshwater drum	11,574	2,505	0.081	2,308	561	0.016	19.9
Other species	1,693	1,255	0.012	127	54	0.001	7.5
Total	169,893	18,084	1.191	96,316	14,420	0.675	56.7

Table B.7. *Estimated angler catch and harvest of fish species and species groups from the PDS zone between 13 Jan and Oct 91.*

	Catch			Harvest			
Species or Group	**Total**	**SE**	**Per Hour**	**Total**	**SE**	**Per Hour**	**% of Catch**
Lake sturgeon	728	302	0.006	0	0	0.000	0.0
Shovelnose sturgeon	204	166	0.002	164	164	0.001	80.6
Unspecified sturgeon	5	5	0.000	0	0	0.000	0.0
Paddlefish	516	187	0.004	0	0	0.000	0.0
Nongame predators	606	279	0.005	163	57	0.001	26.8
Mooneye and goldeye	2,664	880	0.020	860	437	0.007	32.3
Common carp	1,432	207	0.011	387	109	0.003	27.0
Carpsuckers	1,808	742	0.014	260	83	0.002	14.4
Buffalos	377	148	0.003	244	134	0.002	64.6
Redhorse and suckers	3,250	714	0.025	1,061	322	0.008	32.7
Bullheads	0	0	0.000	0	0	0.000	–
Channel catfish	15,095	4,033	0.114	9,568	3,214	0.073	63.4
Flathead catfish	173	89	0.001	141	87	0.001	81.6
Northern pike	1,913	753	0.015	694	615	0.005	36.3
Muskellunge	41	20	0.000	0	0	0.000	0.0
White and yellow bass	18,280	6,830	0.139	13,297	6,722	0.101	72.7
Misc. panfish	609	261	0.005	215	80	0.002	35.3
Bluegill	36,698	6,905	0.278	33,961	6,868	0.258	92.5
Smallmouth bass	8,324	1,529	0.063	1,080	399	0.008	13.0
Largemouth bass	3,117	669	0.024	305	248	0.002	9.8
Crappies	3,117	723	0.024	1,891	604	0.014	60.7
Sauger	5,102	732	0.039	1,851	368	0.014	36.3
Walleye	14,802	1,887	0.112	2,551	441	0.019	17.2
Saugeye	33	20	0.000	15	15	0.000	45.5
Freshwater drum	17,281	2,218	0.131	7,025	1,515	0.053	40.7
Other species	103	42	0.001	50	31	0.000	48.1
Total	136,281	11,212	1.034	75,783	10,327	0.575	55.6

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Acknowledgments

We thank Tom Pellett for helping initiate this study, and for advice and assistance during all phases of the survey. Gordie Priegel also played an important role in seeing that the survey was adequately financed and administered. Mike Staggs provided many helpful comments on survey design and analysis. Don Fago supplied information on water temperatures, walleye and sauger tag returns, and walleye and sauger movement patterns. Creel clerks Bill Halverson, Scott McCumber, Pat Lenz, Lynda Cutts, David Hoffman, and Jenny Huebsch collected most of the data used in this study. Dave Driekosen, Mike Duerst, Don Fago, Paul Kanehl, Kurt Welke, and many other DNR employees helped tag walleye and sauger for the exploitation estimates. Mike Staggs, Tom Pellett, and Gordie Priegel made useful comments on an earlier draft of this manuscript. Funding for this study was provided in part by the WDNR Bureau of Fisheries Management and the Sport Fish Restoration Program, Studies FMB27, RS044, and RS512.

About the Authors

Paul Rasmussen is the biometrician for the Bureau of Research, a position he has held since joining the DNR in 1987. Paul earned a M.S. degree in statistics from the University of Wisconsin-Madison, a M.S. degree in Zoology from the University of Wisconsin-Madison, and a B.S. degree in Biology from Macalester College, St. Paul, Minnesota.

Jean Unmuth is a Research Scientist for the Fish Research Section, currently working on lake ecosystems. She previously was the field and data coordinator for the Lower Wisconsin River creel survey. She began working for the DNR in 1988. Jean earned a B.S. degree in Forestry from the University of Wisconsin-Stevens Point.

John Lyons currently supervises the Rivers and Streams Research Group of the Fish Research Section. He previously was the Special Projects Leader for the Section, focusing on warmwater streams and rivers. He joined the DNR in 1985. John earned Ph.D. and M.S. degrees in Zoology from the University of Wisconsin-Madison, and a B.S. degree in Biology from Union College, Schenectady, New York.

Gene Van Dyck is the Area Fish Manager for the Dodgeville Area, which includes the Lower Wisconsin River. He has held this position since joining the DNR in 1968. He earned a B.S. degree in Wildlife Management, with a minor in Fisheries Management, from Kansas State University, Manhattan.

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PUBL-RS-160 94