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Abstract.–Wakeley Lake has been managed with catch-and-release regulations for all species of fish, walk-in access, and other special rules since it passed from private to public ownership. Major goals were to maintain high-quality populations of largemouth bass *Micropterus salmoides*, northern pike *Esox lucius*, and sunfishes *Lepomis spp.*; maintain high-quality fisheries; and preserve a semi-wilderness setting. Surveys of fish populations were conducted prior to public access in 1986 and 1987, and after public access and special regulations were in effect in 1990 and 1997. Surveys of angling were conducted in 1987, 1990, and 1997, during the first, fourth, and eleventh years of public fishing. Trends in population and angling data indicated the largemouth bass population and fishery have been maintained or improved. Northern pike numbers and fishing quality diminished during the 1990s but the population has the same size structure. Bluegill *Lepomis macrochirus* and pumpkinseed *Lepomis gibbosus* populations and fisheries remained excellent. However, growth of largemouth bass, northern pike, and bluegill declined during the 1990s. Hooking mortality appeared to be very low. Extensive recycling of largemouth bass and northern pike was evidenced by frequency of tag returns and annual angling catches exceeding estimated spring populations by factors of 2-3 times. Anglers visiting the lake consistently expressed strong support for the regulations at Wakeley Lake and catch-and-release angling in general. These regulations have been very successful and should be continued at Wakeley Lake. The same management concepts should be extended to other lakes with equivalent opportunities.

On 5 May 1986, a tract of 1,415 acres in Crawford County, Michigan, was purchased by the United States Forest Service (USFS) for addition to the Huron-Manistee National Forest. Wakeley Lake, located in T26N R2W Sec 23, was included in the tract. The lake had been only lightly fished under private ownership and was known to contain exceptional numbers of large bluegill *Lepomis macrochirus*, pumpkinseed *Lepomis gibbosus*, northern pike *Esox lucius*, and largemouth bass *Micropterus salmoides*. The lake also provided forage fish for bald eagle *Haliaeetus leucocephalus*, osprey *Pandion haliaetus*, and a pair of common loons *Gavia immer*.

The unique fisheries potential of the lake was immediately recognized, and it was protected from public angling until a management plan could be developed jointly by the USFS and the Fisheries Division, Michigan Department of Natural Resources (MDNR). The plan, implemented in 1987, paralleled the highly successful strategy used at the Sylvania Tract in the Ottawa National Forest since 1969 (Schneider and Juetten 1989). Goals were to maintain high densities and proportions of large

fish, excellent catch rates for anglers while allowing modest fishing pressure, and a semi-wilderness atmosphere. An additional goal was to protect populations of eagles and loons, which were threatened species in Michigan. These key restrictions were adopted:

- Catch-and-release for all species of fish
- An abbreviated 11-week fishing season, 15 June - 31 August
- Only artificial lures and flies allowed
- Walk-in access (except handicapped anglers were allowed motorized access)
- Boats may not be stored overnight except by campers
- No gasoline motors
- An area of lake was off-limits during loon nesting

In addition, the semi-wilderness setting of the lake was enhanced by removal of the only building and by limiting camping to a few primitive sites with pit toilets and without drinking water. The setting is serene except for occasional noises from anglers, highway, and military maneuvers associated with the Camp Grayling National Guard Base. Access to the lake is obtained by parking in a lot along highway M-72 and hiking 15 minutes down a two-track road. Enforcement of rules is enhanced by the presence of a USFS house at the parking lot and occasional patrols by the resident and Conservation Officers. Policing by anglers anxious to protect their good fishing is probably important also. Enforcement is aided by the short fishing season that concentrates fishing activity.

Wakeley Lake is of the shallow, warmwater type. The light brown water has a maximum depth of only 9 feet, Secchi disk transparency is typically 5-6 feet, and alkalinity is 46 ppm. Water lilies and various pondweeds grow across nearly the entire bottom. Area of the lake proper is estimated at 168 acres. In addition, there is an extensive wetland along the north shore. Flooded trees occur in the southwest corner, apparently drowned when a small dam (about 5-foot head) was constructed across the outlet many years ago. About 2 acres of the lake were dredged and dyked in 1984, but the depressions quickly filled with soft sediments.

Wakeley Lake is vulnerable to winterkill. The last reported winterkill was in the 1970s when a portion of the fish died. Since the lake came into public ownership, MDNR district personnel have monitored dissolved oxygen concentrations during severe winters. In February and March 1996, dissolved oxygen levels of <2 ppm at depths of 2-5 feet prompted the drilling of many holes in the ice to allow atmospheric oxygen to replenish lake water. Winterkill was averted.

During the early 1980s, lake owners attempted to improve gamefish populations. Approximately 25,000 yellow perch *Perca flavescens* were stocked and nets were used to remove 500-1,000 stunted northern pike and 5,000 bullheads *Ameiurus*. Perch remained sparse, northern pike size reportedly improved, and the bullhead population was effectively reduced.

This report will evaluate the success of the fisheries management plan, and of the catch-and-release regulation in particular, during the first 10 years of public management of Wakeley Lake. An evaluation plan was developed in 1986 that called for periodic surveys of both fish and fishing. Design and analysis duties were delegated to researchers, field work was delegated to District 7 MDNR managers and USFS personnel. General goals of the evaluation were to determine if good angling and good fish populations could be maintained indefinitely and if this management strategy was popular. Specific attributes that were monitored included:

- Fishery characteristics of angling pressure (use), angler satisfaction, catch rates, species of fish sought, and methods
- Population characteristics for each important species, including abundance (measured by population estimates and catch rates), proportion of large fish, and growth rate
- Recapture rates, which relate number of fish caught by anglers to number of fish available in the populations

Data were collected prior to any effects of public angling (referred to as pre-years), and during early, mid, and late years of the fishery

(referred to as post-years). It was expected that after 10 years of monitoring any trends should have become evident and stabilized.

Methods

Fishery Surveys

Surveys of angling were conducted in 1987 (first year of public fishing), 1990 (fourth year), and 1997 (eleventh year). Angling effort and catch were estimated during the first week of each fishing year (June 15-21) by an intensive census, and during the rest of the fishing year (June 22-August 31) by a random census.

For the intensive census, a clerk stationed at the lake from dawn until dark was able to interview virtually every angler. This was facilitated by a single access point, very little night fishing activity, and the clerk camping at the lake the night before opening day in case fishing activity began at midnight. Catch and effort estimates for the first week were simply the sums of the interview data and had no statistical variance.

For the random census, revised standard techniques were used to calculate fishing pressure and catch (Lockwood et al. 1997). The clerks sampled fishing activity on a pre-determined random schedule from 6 a.m. to 11 p.m., on three out of five weekdays, both weekend days, and 4 July. Weekends and the 4 July holiday were sampled more intensively because fishing pressure was higher. Catch per hour (CPH) was determined for all methods and modes of angling combined, from interviews after fishing trips. Fishing effort was calculated from average length of a fishing trip and average number of anglers present per hour; the latter was based on bi-hourly counts of anglers made over a 16-hour fishing day. Counts of vehicles in the parking lot were also made periodically for correlation with fishing activity. Additional data were obtained outside of the scheduled census hours from interview cards (available at a box near the lake) that were voluntarily completed by some anglers.

Since anglers had to immediately release all fish caught, the interviewer had to rely on each angler's recall and honesty. Some anglers had difficulty identifying bluegill and pumpkinseed, so those species were pooled as "sunfishes." Accuracy of reporting during the first week of fishing (when large catches were made) was enhanced by asking some anglers (especially campers) to be "cooperators". They were issued measuring boards, pencils, and clipboards, and were asked to record data while they fished. Specifically, cooperators recorded fish species, lengths, tags, fin clips, and how severely each fish appeared to be injured by hooking. These hooking condition ranks were established: excellent (lip hooked); good (little damage apparent); poor (punctured gill, skull, esophagus); and bad (will probably die).

All anglers were asked three opinion questions as time permitted:

1. How would you rank today's fishing on a scale of excellent, good, satisfactory, or poor?
2. Should these special regulations be continued at Wakeley Lake?
3. Would you support catch-and-release regulations at some other lakes for either largemouth bass, northern pike, bluegill, or trout?

Trout were included for comparison with warmwater species because the concept of catch-and-release trout angling was already well established in Michigan, especially for the nearby Au Sable River. Bias in reporting and ranking probably existed in the interview responses but, at the least, these data provided indices of trends through time. A copy of the 1997 interview form is shown in Appendix 1.

Fish Population Surveys

Surveys of fish populations were conducted in May-June, prior to public angling (1986 and 1987) and 3 and 10 years after angling began (1990 and 1997). Sampling gear included trap nets (pots 3-feet x 5-feet with 1.5-inch stretched mesh), large-mesh fyke nets (pots 4-foot diameter with 2-inch stretched mesh), and small-mesh fyke nets (pots 4-foot diameter with 0.7-inch stretched mesh). Each netting period was followed by a period of night electrofishing with a 240-V DC boomshocker. Total length of all

fish was either measured to inch group (i.e., 1.0 to 1.9 = 1-inch group, etc.) for length-frequency analysis, or to 0.1 inch for age and growth analysis. Scale samples were collected from the latter fish, impressed in plastic, enlarged, number of annuli were counted, and average length at each age was computed. Length-at-age statistics for Wakeley Lake fish were compared to State of Michigan averages (Schneider et al. 1981).

Fish were marked to determine population estimates and multiple recaptures by anglers ("recycling" rates). Fish caught in nets were marked by clipping the top lobe of the caudal fin. In addition, in 1986, 1987, and 1990, numbered Floy anchor tags were inserted into the base of the dorsal fins of largemouth bass over 10 inches and northern pike over 18 inches in length. Fish caught by electrofishing were marked with a bottom caudal fin clip. Mark-recapture population estimates were attempted each year using the Chapman modification of the Petersen formula or the Schumacher-Eschmeyer method (Ricker 1975). Recaptures were sparse and it was necessary to pool data into broad size groups to obtain estimates. Pooling of size groups often tends to underestimate the total population if larger fish are more readily recaptured in survey gear than smaller fish, as is often the case (Latta 1959). However, the estimates provided, at least, indices of population trends.

Recycling rates by anglers were estimated from incomplete reports of recaptures of tagged largemouth bass and northern pike. In addition, mark-recapture population estimates in the spring were compared to angler catch estimates during the following summer. Two methods were used. The fairest comparison is between spring population estimates and catch estimates made soon afterward, 15-21 June. The latter catch estimates were multiplied by the proportion of the angler's catch which exceeded 10 inches (largemouth bass), 17 inches (northern pike), or 6 inches (sunfish), so that catch estimates and population estimates represented comparable-sized fish. Comparisons between spring population estimates and catches for the entire summer were probably less reliable because some fish grow to catchable size during the summer and others die and become unavailable, but on average these effects may balance out.

Results

Fishery Characteristics

Large numbers of anglers were attracted to Wakeley Lake for the prospect of fishing "virgin" waters, especially on opening day each year. Fishing pressure was 318 angler hours (1.9 hours per acre) on 15 June 1987, but that was exceeded in 1997, when opening day fell on a weekend (Table 1). Annual (11-week) fishing pressure was stable at between 3,292 and 3,994 hours (19.6-23.8 hours per acre) (Table 2). Total catch held at between 5,000 and 6,700 fish per year, and CPH remained good at 1.4 to 1.7 fish per hour.

Anglers expressed a high degree of satisfaction with the fishery and the catch-and-release regulation each year. Fishing was exceptional on opening day in 1987, when almost all anglers ranked fishing quality as excellent (54%) or good (41%). For the first week, 84% of the anglers ranked fishing as either excellent or good, and the average for 1987 was 71% (Table 3). Satisfaction declined in subsequent years but remained relatively high. In 1997, 54% said fishing was excellent or good during the first week and the annual average was 60%. Support for continuation of catch-and-release regulations at Wakeley Lake increased from 86% in 1987 to 96% in 1997 (Table 3). Likewise, by 1997 over 89% of the anglers said they would support more catch-and-release lakes for sport species, even bluegill (Table 3). Since these questions were asked only of anglers visiting Wakeley Lake, these statistics under-represent anglers not in favor of catch-and-release who usually fished elsewhere.

The primary attractions at Wakeley Lake were largemouth bass and northern pike, but the lake was also noted for very large bluegill and pumpkinseed. By 1997, more anglers were targeting panfish and largemouth bass (Table 4).

Only artificial lures and flies were allowed. Therefore, spin casting (63%) and fly casting (23%) were the primary methods used in 1997 and in other years.

Wakeley Lake affords little opportunity for wading or fishing from shore. Consequently, lightweight boats and canoes were preferred, and float tubes increased in popularity. By 1997, 63% of anglers used boats or canoes, 20% used float tubes, and 15% fished from shore. The arduous 15-minute portage discouraged the less hardy angler and prompted the purchase or construction of ingenious carts to transport equipment. As is typical of most fisheries, male anglers predominated (93%).

The number of vehicles in the parking lot was a fair indicator of number of anglers on Wakeley Lake during the 1997 fishing season. A regression of counts of anglers against counts of vehicles at approximately the same time had considerable scatter (r^2=0.64) due to other users of the area. Other users included bikers, hikers, and bird watchers. In future years, fishing pressure could be estimated by multiplying vehicle counts by 0.67 (i.e., number of anglers on Wakeley Lake equals two-thirds of the number of vehicles in the lot).

Species Trends

Largemouth bass–Bass fishery data indicated improvements rather than declines occurred under catch-and-release. For first week statistics (Table 1), number of largemouth bass caught in 1997 was higher than in 1987 and largemouth bass CPH was as high. Annual statistics likewise indicated largemouth bass fishing improved (Table 2). Largemouth bass CPH was 0.42 in 1987, 0.35 in 1990, and 0.68 in 1997. Opening day in 1987 had the highest CPH, 0.80, but the fourth day in 1987 and days three and seven in 1997 had CPH values over 0.71 CPH (Figure 3). Thus, there was not a marked decline in largemouth bass vulnerability after opening day at Wakeley Lake compared to catch-and-keep fisheries at Mill Lake and elsewhere (Bennett 1954; Westers 1963; Schneider 1973).

Largemouth bass population characteristics also were better in 1997 than in pre years (1986-87). Both the proportion and density of large bass (>15 inches long) increased. The proportion of large bass caught by large mesh fyke nets increased from 11-24% in 1986-87 to 51-60% in 1990-97 (Figure 1 and Appendix 2). The proportion of large bass caught by anglers also improved (Figure 2 and Appendix 3). However, few largemouth bass exceeded 20 inches in any year. Mark-recapture population estimates also indicated that large bass increased in both absolute number and proportion. In 1997, the estimated number of largemouth bass over 15 inches was 634 (3.8 per acre), eight times higher than in pre years (Table 5). The population of largemouth bass >10 inches varied without trend between 451 and 1,281 fish (2.7-7.6 per acre) during the 1986-97 period.

Largemouth bass in Wakeley Lake grew more rapidly than the State of Michigan average in 1986-90 (Table 6 and Appendix 4). By 1997, largemouth bass growth had declined to 0.9 inches below state average. Largemouth bass may have been even older and slower growing than they appeared to be from patterns on their scales. In 1997, four largemouth bass 16.1 to 17.7 inches long were recaptured with remnants of tags inserted 10 or 11 years earlier. Those fish were no less than 10 inches long and 3 years old when tagged. They had grown no more than 8 inches in 11 years, and were no less than 13 years old when recaptured.

Northern pike–Angling statistics showed a declining trend since 1987 (Table 2). Number of northern pike caught declined by 2-3 fold and CPH declined by 3-4 fold. Mark-and-recapture population estimates likewise suggested a smaller population in 1997, but all northern pike estimates were based on sparse data (Table 5). The low northern pike population in 1997 may have been due to a natural cycle or to hooking mortality. Anglers judged that 8% of the northern pike were released in poor or bad condition, compared to 3% of the largemouth bass and sunfish (Table 7).

Length distributions of northern pike caught by either nets or anglers have remained the same (Figures 4 and 5). The proportion of northern pike over 24 inches was 7-27% for pre-fishing years and 6-29% for fishing years (Appendices 2 and 3). Pike grew so slowly that few reached 30 inches in length (Table 6 and Appendix 4). Growth index declined from 2 inches below the state average rate in 1986 to almost 3 inches below state average by 1997 (Table 6).

Sunfish–Bluegill and pumpkinseed populations and fisheries improved during years of catch-and-release regulations. Estimated populations of bluegill and pumpkinseed >6 inches increased in recent years to 5,201 (31 per acre) and 1,003 (6 per acre), respectively (Table 5). Angling catch and CPH also improved compared to 1987 (Table 2). The improvement in fishery statistics can be partially attributed to an increase in fishing specifically for sunfish, as mentioned above. Sunfish size distributions also improved (Figure 7 and Appendix 2). Pumpkinseed size improved from excellent to spectacular, with numerous 10-inch fish present by 1997 (Figure 7 and Appendix 2). Bluegill average size generally improved, but bluegill greater than 10 inches were less common in 1990 and 1997 (Figure 8 and Appendix 2). Growth of pumpkinseed equaled or exceeded the state average rate during 1986-97 (Table 6). Meanwhile, the growth index of bluegill declined to 1.1 inches below state average (Table 6).

Recycling

Anglers caught high proportions of the fish one or more times. For example, of 204 largemouth bass and 98 northern pike tagged while netting prior to the 1987 angling season, anglers reported the recapture of 35% of the largemouth bass and 26% of the northern pike that year. One largemouth bass was caught four times, another three times, and seven were caught twice. Seven northern pike were caught twice. These are minimum recapture figures that are based on incomplete reporting.

The importance of multiple recaptures to angling quality is best demonstrated by comparing catches to populations (Table 8). For largemouth bass, comparisons indicated that first week catches sometimes equaled the estimated population of available largemouth bass over 10 inches, and the annual catch exceeded the spring population by a factor of 2-3 times. Comparable ratios were nearly as high for northern pike. For sunfish, the ratios were much lower, with less than 10% of the population caught during the first week of fishing.

Discussion

Results indicated the management strategy at Wakeley Lake, and catch-and-release regulations in particular, successfully met the general goals of maintaining good angling, quality fish populations, and popular support. This strategy was developed from considerable background information collected from Michigan and elsewhere.

Prior Experiences

Prior experience in Michigan had clearly demonstrated that lightly exploited fish populations were very vulnerable to angling. Opening of these virgin lakes to normal levels of harvest, as by passage from private to public ownership, resulted in extraordinarily high fishing pressure and catch, and rapidly declining CPH. The populations, which often initially had high densities of large fish, usually became much reduced. This was especially evident during the first week and year of angling. Case histories from the Rifle River Area, Third Sister Lake, two ponds, Mill Lake, and the Sylvania Tract provide examples.

The Rifle River Area, formerly a lightly fished private estate, was opened to public harvest in 1945 (Patriarche 1960). The three primary lakes attracted considerable fishing pressure (18-144 hours per acre) and provided unusually good catches during the first year, then the fisheries declined (Table 9). Comparing 1946-56 averages to 1945 statistics, angling pressure declined by 42%, total yield (pounds per acre) declined by 62%, and overall fishing quality (pounds harvested annually per acre) fell by 33%. Harvest rates, CPH, and average size of largemouth bass, smallmouth bass *Micropterus dolomieui*, and northern pike typically declined by 50% (Table 9; Patriarche 1960). Most panfish populations and fisheries declined in similar fashion, but sometimes increases in yellow perch, black crappie *Pomoxis nigromaculatus*, and rock *bass Ambloplites rupestris* occurred, perhaps in response to declining predators. Catches of predators were especially high during the first few weeks (Patriarche 1960). It appeared that

fish removals at Jewett Lake, at least, were not compensated for by improvements in growth of remaining fish (Schneider 1995).

Third Sister Lake is located on University of Michigan property with restricted access. During a 22-day period, 8.5 hours per acre of experimental fishing removed 31% of the largemouth bass greater than 10 inches in length and 24% of the bluegill over 6 inches (Brown and Ball 1942). These percentages could be inflated because they assume all remaining fish were accounted for by a subsequent population census using rotenone.

A study of stunted largemouth bass at two small, previously unfished ponds (Westers 1963) documented declining catchability even though all fish were released back into the ponds. At Dix Pond, largemouth bass CPHs were 8.5, 3.9, 1.9, 0.8, and 0.9 on fishing days 1,2,3,10, and 16, respectively. Twenty-two percent of all estimated largemouth bass present were caught once under intensive fishing pressure of 41.6 hours per acre. Recapture rate was 5%. At Rash Pond, angling pressure of 182 hours per acre captured 22% of the largemouth bass population. Declining catch rate in both ponds was attributed to both previously hooked and unhooked largemouth bass developing "hook resistance" (wariness). Hooked largemouth bass held in a live crate for several hours experienced a low mortality rate (3.5%).

At Mill Lake, reopened to public fishing in 1969 after 5 years of complete protection, extraordinary numbers of anglers were attracted and high harvests were recorded in a carnival atmosphere (Schneider 1973). This lake is located in populated southern Michigan but is not close to major cities. During the first 3 days, the lake received 39 hours per acre of fishing pressure, which was about one-third the norm for an entire year. About 35% of the largemouth bass population and substantial proportions of the other species were harvested. Catch rates declined dramatically as fish were removed and survivors apparently became more wary.

A study at three test lakes in the Sylvania Tract prior to opening the area to public angling demonstrated the dynamics of largemouth bass populations in unproductive northern waters (Clady 1975). Removal of 13-20% of the adult largemouth and smallmouth bass did not stimulate a compensatory response in the form of improved growth or decreased natural mortality. Consequently, populations in the test lakes declined and were not replaced during the 3-year study. Monitoring did not continue long enough to determine if recruitment would increase. Clady and co-workers (including myself) observed that the largemouth bass were naïve and could be readily caught by hook and line. Wisely, the Sylvania lakes were then opened with very restrictive regulations in place (Clady et al. 1975; Latta 1975). Combinations of catch-and-release, trophy minimum size limits, and low possession limits were successfully used. However, catch-and-release for bass (primarily smallmouth) has been the most successful strategy for preserving large bass and good fishing (Schneider and Juetten 1989; Miller 1992).

The same trends of high vulnerability of naive largemouth bass, smallmouth bass and northern pike to angling, declining catch rates due to removal and increased wariness, and significant reductions in fish populations have been observed outside of Michigan as well (Bennett 1954; Anderson and Heman 1969; Beukema 1970; Goedde and Coble 1981). A compensatory response for both the fish population and the fishery is that as angling quality declines, fishing pressure usually declines also (Byrd 1959). Anglers tend to shift to waters perceived to offer better fishing, thereby allowing the population and fishery to rebound somewhat. In one case, anglers perceived that waters still containing 6 largemouth bass per acre had been fished out (Lagler and DeRoth 1953).

Certain individual fish within largemouth and smallmouth bass populations are difficult to catch and others are easy to catch (Anderson and Heman 1969; Clapp and Clark 1989; Burkett et al. 1986). Fish that are easy to catch are the most important ones for maintaining fishing quality. Clapp and Clark (1989) noted that 35% of the smallmouth bass in experimental channels were never caught, and 18% of the individuals supplied 54% of the number caught and released. Fish that learned to avoid baited fishing hooks and lures sometimes remained hard to catch for one year

(Bennett 1954; Anderson and Heman 1969; Coble et al. 1985). Annual catches twice as high as available populations have been have been noted for largemouth bass in other waters (Weithman and Anderson 1980; Burkett et al. 1986). Results at Wakeley Lake suggested that recycling rates for largemouth bass and northern pike were 2 to 3 times the available fish populations, and tagging confirmed that some individual fish were caught multiple times.

Artificial lure restrictions contribute to the success of catch-and-release fisheries. Hooking mortality of fish caught on artificial lures tends to be relatively low. Under typical Michigan temperature conditions (rarely over 85°F), hooking mortality probably averages 10% or less for largemouth bass (Clapp and Clark 1989; Green et al. 1987), about 15% for northern pike (Muoneke 1992; Beukema 1970; Storck and Newman 1992), and less than 25% for sunfish (Siewert and Cave 1990; Burdick and Wydoski 1988). The subjective evaluations of hooking injuries by Wakeley Lake anglers suggested that hooking mortality was less than 10% for all species.

The Wakeley Lake Experience

At the start of the Wakeley Lake experiment, the biological issue was whether catch-and-release regulations would sufficiently protect fish so that relatively high populations and catch rates could be maintained indefinitely. I expected a low level of fish mortality due to poaching and accidental hooking deaths. But how many fish would become harder to catch, rather than being recaptured multiple times? The challenge was to maintain good fishing for novice anglers by maintaining a large supply of naive fish. Experienced anglers can usually find good fishing on most days.

Results showed that good fish populations, high catch rates, and high satisfaction rates were maintained at Wakeley Lake—especially when compared to the depletion that would have occurred with normal harvest regulations and fishing pressure. Northern pike was the only species whose abundance and catch rate were clearly lower in the last year than in the first year. Abundance of larger largemouth bass and CPH improved over time. Overall fishing quality remained high over the 11 years of study, with 28% of anglers ranking fishing as excellent in the last year compared to 39% in the first year (Table 3).

Excellent fishing was more than CPH in the minds of many anglers. Few anglers thought fishing was poor when catch rate exceeded 0.5 fish per hour at Wakeley Lake (Table 10). Catch and rank were not closely related. Many anglers gave high ranks to trips with low catches. Relative seclusion of the lake, low usage, awareness that large fish were lurking, and the chance to see loons and eagles surely contributed to the favorable experience.

The quality of fishing in Wakeley Lake for top predator species was high compared to Michigan lakes with normal harvest regulations. The combined catch rate of largemouth bass and northern pike at Wakeley Lake varied annually from 0.53 to 1.12 fish per angler-hour (Table 2). Normal lakes provide less than 0.2 largemouth bass per angler-hour, plus trace amounts of northern pike (Schneider and Juetten 1989). Catch-and-release lakes in the Sylvania Tract also provided excellent fishing for top predators (primarily smallmouth bass, some largemouth bass, and few northern pike). Catch rates there ranged between 0.60 and 2.04 fish per angler-hour for the eight lakes with the best data sets (Schneider and Juetten 1989; Miller 1992).

Densities of largemouth bass and northern pike in Wakeley Lake were not exceptionally high compared to other Michigan lakes. The population density of largemouth bass >10 inches in Wakeley Lake, at 2.7-7.6 largemouth bass per acre, was exceeded at five other unexploited lakes and three exploited lakes (Table 11). The population of northern pike >17 inches in Wakeley Lake varied from 1.7-10.3 northern pike per acre, again not extraordinarily high (Table 12).

Fishing pressure was relatively low at Wakeley Lake. Opening day fishing pressure was 1.9 hours per acre at Wakeley Lake, compared to 15.2 hours per acre at Mill Lake (Schneider 1973). Annual pressure was about 20 hours per acre for the 78-day season at Wakeley Lake. Small lakes in the region with normal accessibility averaged 69 hours per acre per year (Ryckman and Lockwood 1985).

Pressure at Wakeley Lake was similar to pressure at the more remote lakes in Sylvania, which ranged from 2 to 30 hours per acre (Schneider and Juetten 1989). Sylvania lakes have a much longer open season, from the third Saturday in April through October, but most fishing occurs within 120 days, mid May to mid September.

Management Implications

It appears that good fishing can be maintained by catch-and-release regulations if daily average pressures do not exceed approximately 0.3 hours per acre. Average daily pressures were 0.1 hours per acre at Wakeley Lake and varied from 0.2 to 0.25 hours per acre at Sylvania lakes. For exploited and more productive Ridge Lake, Illinois, Bennett (1954) noted that daily pressures less than 0.4 hours per acre maintained good largemouth bass fishing and pressures in excess of 1.8 did not.

While catch-and-release regulations usually protect exceptional populations and fisheries, restoring those characteristics to lakes that already have been depleted by exploitation may be a slow process requiring anglers to curtail fishing activity as well as stop harvesting. Coolwater and warmwater fish have relatively long life spans. Computer simulations indicate several years must elapse before reductions in annual mortality rate are reflected in noticeable improvements in fish populations. Many years may be required before recruitment adjusts and a new population equilibrium is achieved. At Mill Lake, closure to all angling for 5 years, combined with chance occurrence of strong year classes, improved both panfish and game fish populations and created exceptional angling when the fishery was reopened (Schneider 1971, 1973). At three stunted bluegill lakes, a combination of thinning bluegill populations with antimycin combined with catch-and-release rules for all species quickly improved all populations and fisheries (Schneider and Lockwood 1997). Benefits continued at least 6 years, and are still being monitored.

Special regulations that allow even a slight amount of harvest seem to be considerably less successful at protecting largemouth bass populations and fisheries than complete no-kill. Initially, trophy regulations for smallmouth bass that allowed the daily harvest of one 18-inch smallmouth bass per angler were tested at some lakes in the Sylvania Tract. After several years, it was concluded that significant loss of large as well as trophy smallmouth bass was taking place (Clady et al. 1975; Latta 1975). Since implementation of catch-and-release rules on those lakes, large bass have been restored (Schneider and Juetten 1989). Trophy regulations provided better protection to lightly fished populations of lake trout *Salvelinus namaycush* and walleye *Stizostedion vitreum* and have been retained (Schneider and Juetten 1989). By contrast, lakes in the McCormick Tract, not far from Sylvania, contained few large bass when they entered public ownership in Craig Lakes State Park. Slot size limits and trophy regulations were applied, but there also they have not produced exceptionally good populations or fisheries for largemouth or smallmouth bass (Schneider and Juetten 1989). Beginning in 1999, catch-and-release regulations will be tested.

Michigan now has 60 warmwater and coolwater lakes being managed with either catch-and-release or very restrictive regulations (Table 13). In addition, there are many lakes in Isle Royale National Park with restrictive fishing. Most of the lakes are in four areas of the Upper Peninsula which were transferred from private to public ownership as large tracts and it was timely, appropriate, and socially acceptable to implement special rules. Every new tract added to public ownership in Michigan for the last 30 years has received serious consideration for catch-and-release status, and that policy should be continued. Some lakes have been added in southern Michigan in recent years, but these lack a wilderness mystique.

As the opportunity arises, more waters should be managed for maximum fish populations and high fishing quality with highly restrictive regulations. Strong—and increasing—angler support for catch-and-release has been documented at both the Sylvania Tract and Wakeley Lake. Anglers polled at Wakeley Lake (Table 3) expressed strong support (>89%) for establishment of more catch-and-release fishing

lakes for largemouth bass, northern pike, trout, and even bluegill. Anglers at less biased sources also have indicated the practice of catch-and-release is widespread in Michigan. In a 1996 survey (Schneider, unpublished), 70% of the anglers reported they usually release 70% of legal bass and 48% of legal northern pike they catch, and approved of the more restrictive higher size limits implemented in 1993.

Success Factors

The success of special regulations at Wakeley Lake may be attributed to these factors:

1. Implementation while the fish populations were still in excellent shape and before public anglers had become accustomed to harvesting fish there. Since fish were more abundant, larger, and easier to catch than in average lakes, anglers were more likely to be supportive of efforts to maintain a high-quality fishery. Since no public anglers had enjoyed harvest privileges during private ownership, none could claim that catch-and-release rules would be a personal hardship.
2. Multiple recapture of fish, so that high catch rates were maintained. The individuals that are the most easily caught are the most important portion of the population to protect because they contribute most to fishing success. While certain fish probably became more wary and harder to catch with exposure to angling, sufficient numbers of "hook happy" fish apparently remained to maintain high catch rates.
3. High compliance, so that the benefits of recycling fish were not offset by losses to poaching. Contributing factors are believed to be strong peer support for catch-and-release, limited accessibility, presence of a residence at the access site, and adequate enforcement by officials.
4. Low hooking mortality, so that the benefits of recycling fish were not offset. Relatively low rates of mortality are attributed to prohibition of live bait fishing and restriction to artificial lures and flies.
5. Low fishing pressure, so that fish would remain relatively easy to catch and the remote atmosphere would be retained. Walk-in access, a short fishing season, and a ban on outboard motors successfully engineered these factors.
6. Enough fishing activity to justify special management. Popular support remained strong among a significant portion of the angling public.
7. The semi-wilderness setting. Many anglers appreciated the opportunity to see unusual wildlife and enjoyed the relative solitude– free from dwellings, recreational boaters, and the hyperactivity prevalent on most lakes.

Recommendations

The special regulations at Wakeley Lake, and especially catch-and-release, should be continued indefinitely for all species. Re-survey fish populations if reports from anglers suggest significant declines are occurring. Poor growth rates observed in 1997 have been offset by high longevity to date, but may eventually cause deterioration in size structure of the fish populations.

As opportunities arise, manage comparable waters with limited access and catch-and-release regulations. Factors to consider are quality of fish populations, aesthetic qualities of the lake, potential fishing pressure, and control of accessibility and compliance. Fish populations in unproductive waters require the most protection.

Acknowledgments

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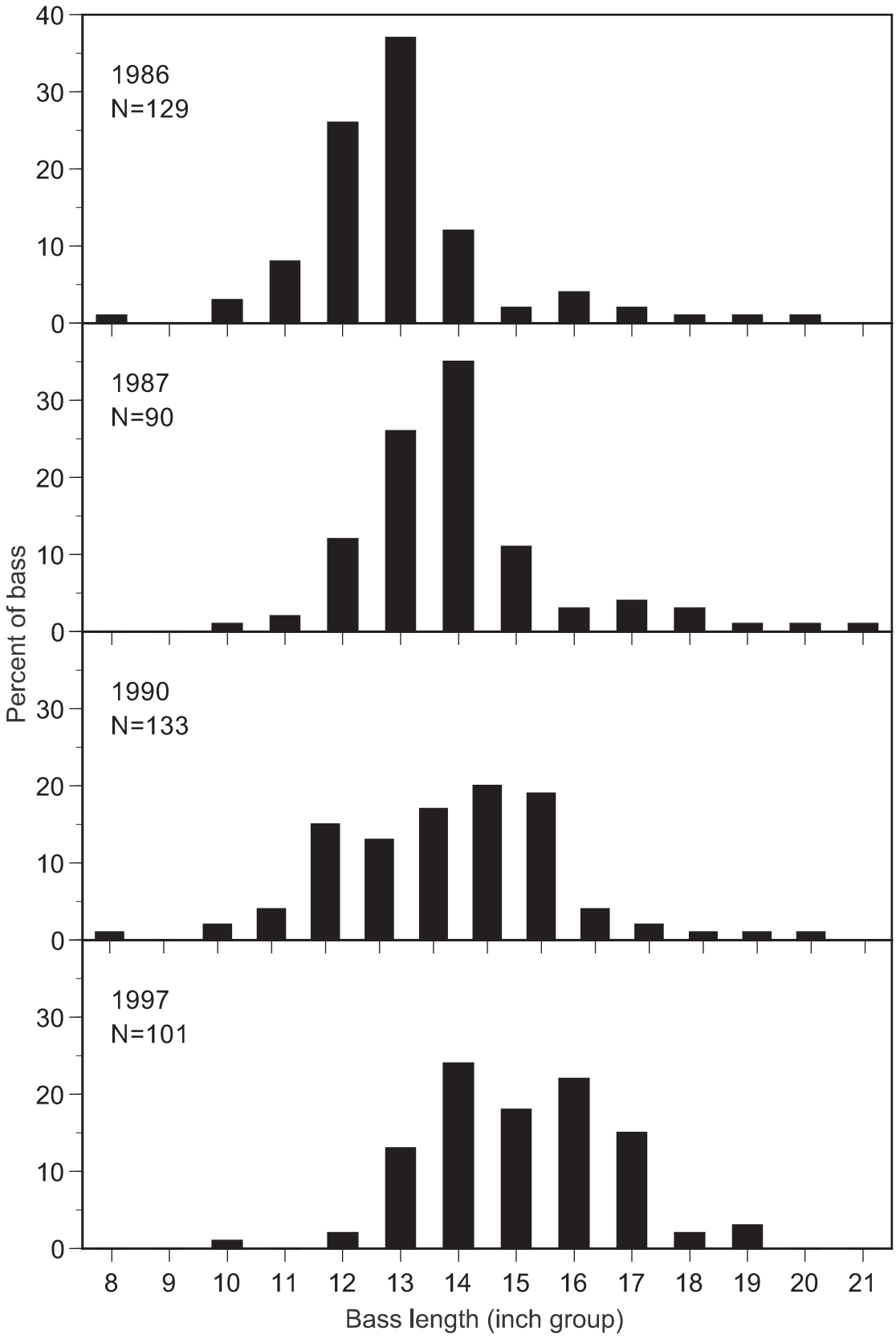

Figure 1.–Length-frequency distributions of largemouth bass caught in large-mesh fyke nets, Wakeley Lake, 1986-97.

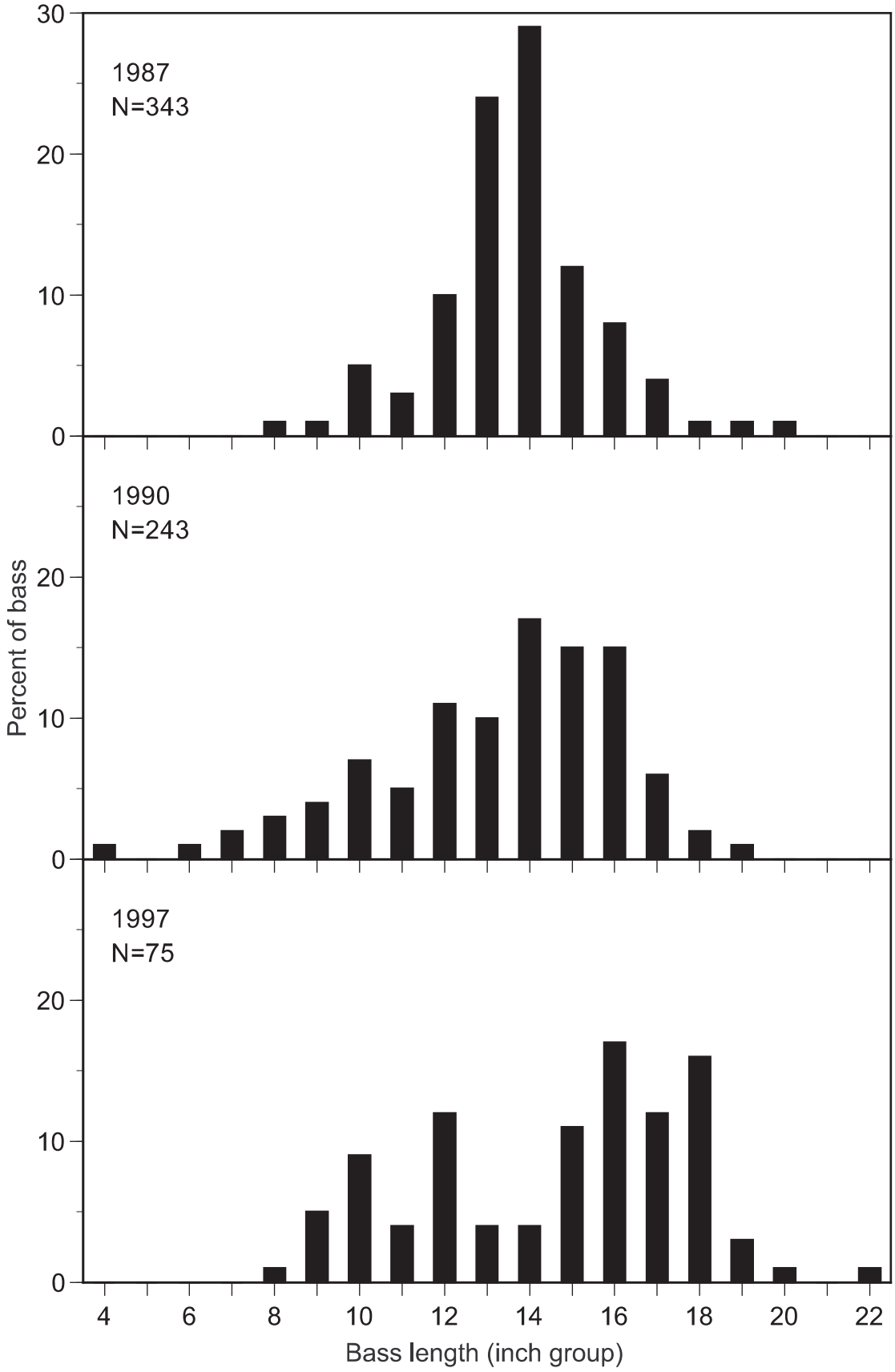

Figure 2.–Length-frequency distributions of largemouth bass caught by anglers, Wakeley Lake, 1987-97.

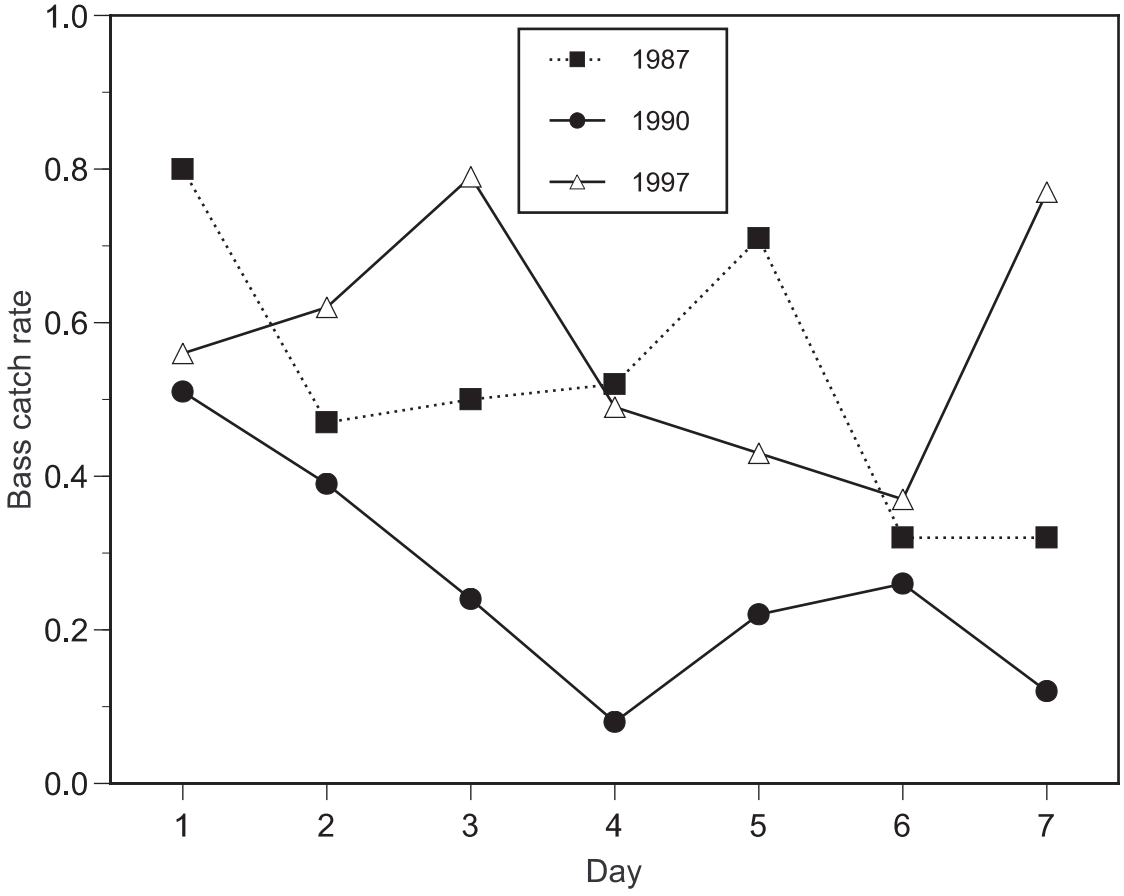

Figure 3.–Daily trends in largemouth bass catch rate (number per angler hour), where day 1 is opening day of angling at Wakeley Lake in 1987, 1990, or 1997.

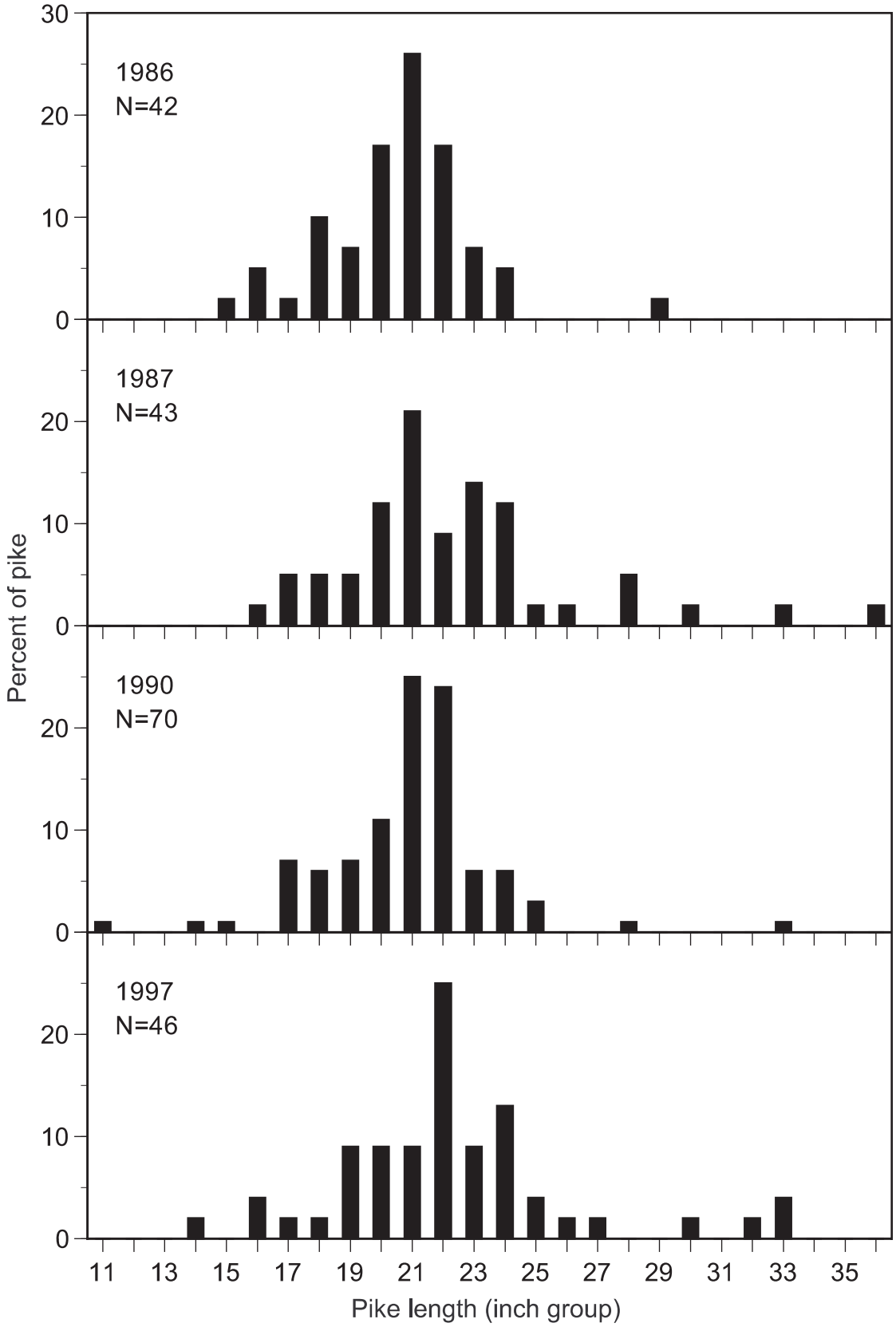

Figure 4.–Length-frequency distributions of northern pike caught in large-mesh fyke nets, Wakeley Lake, 1986-97.

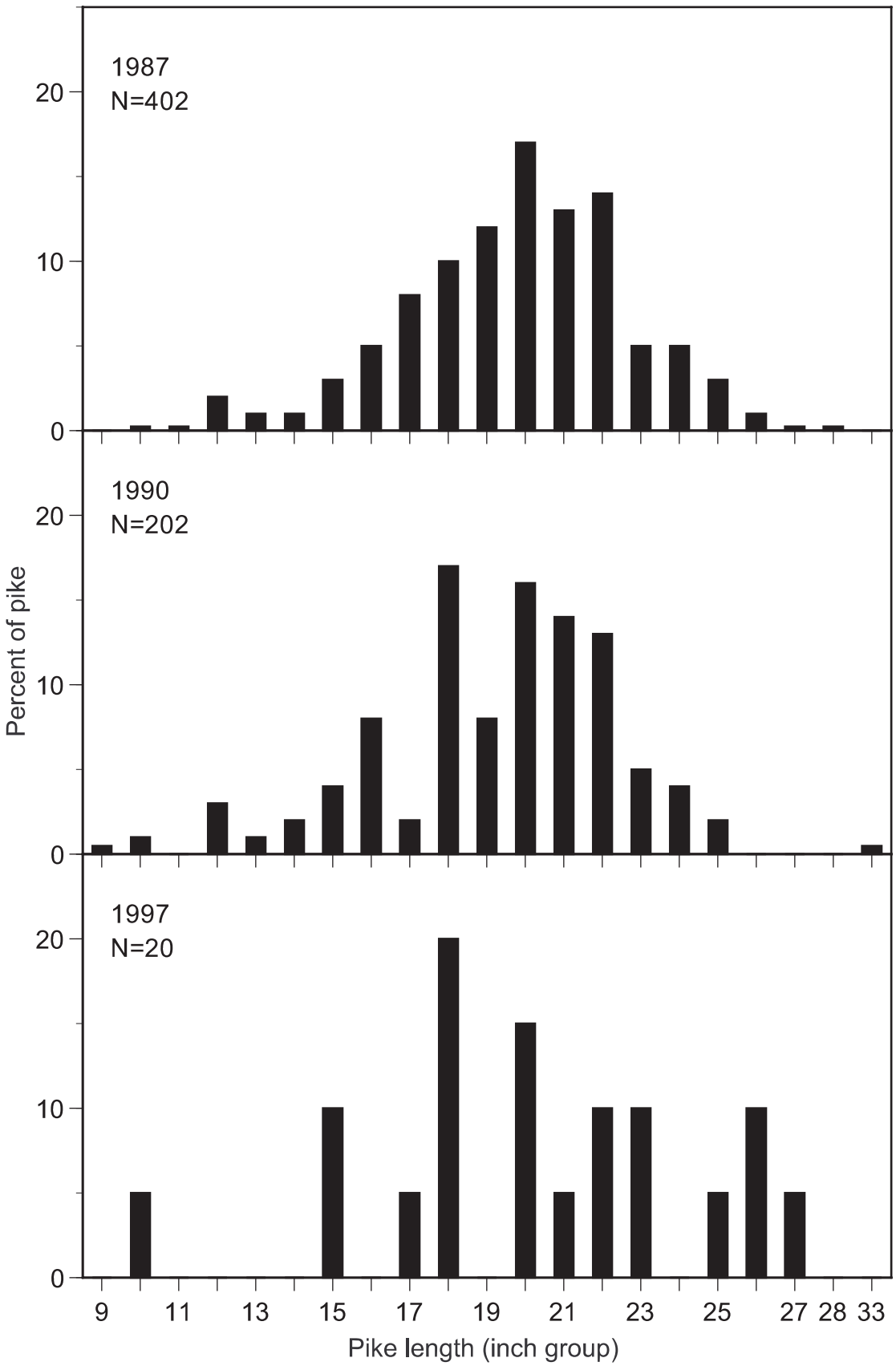

Figure 5.–Length-frequency distributions of northern pike caught by anglers, Wakeley Lake, 1986-97.

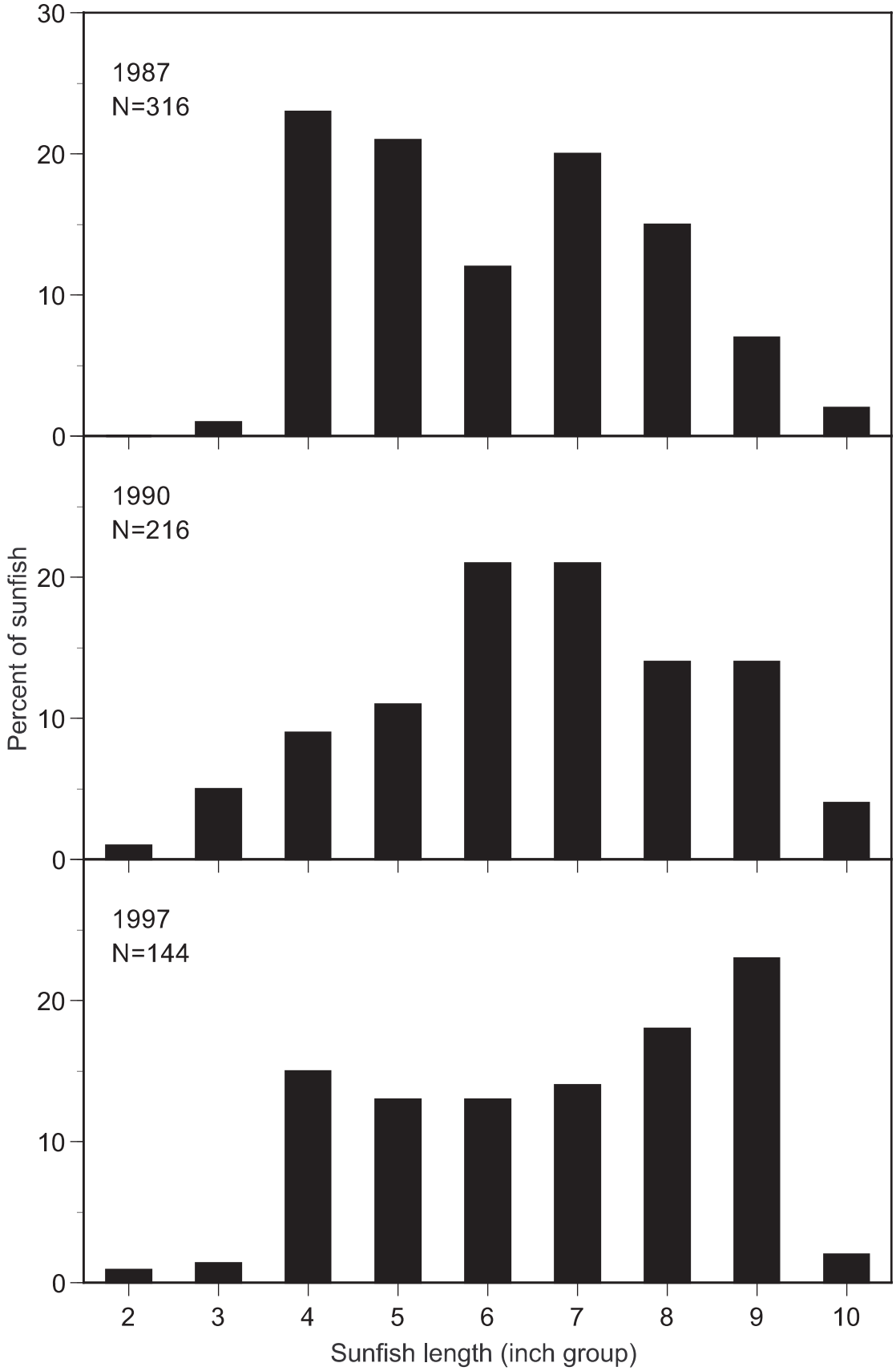

Figure 6.–Length-frequency distributions of sunfishes (bluegill and pumpkinseed) caught by anglers, Wakeley Lake, 1987-97.

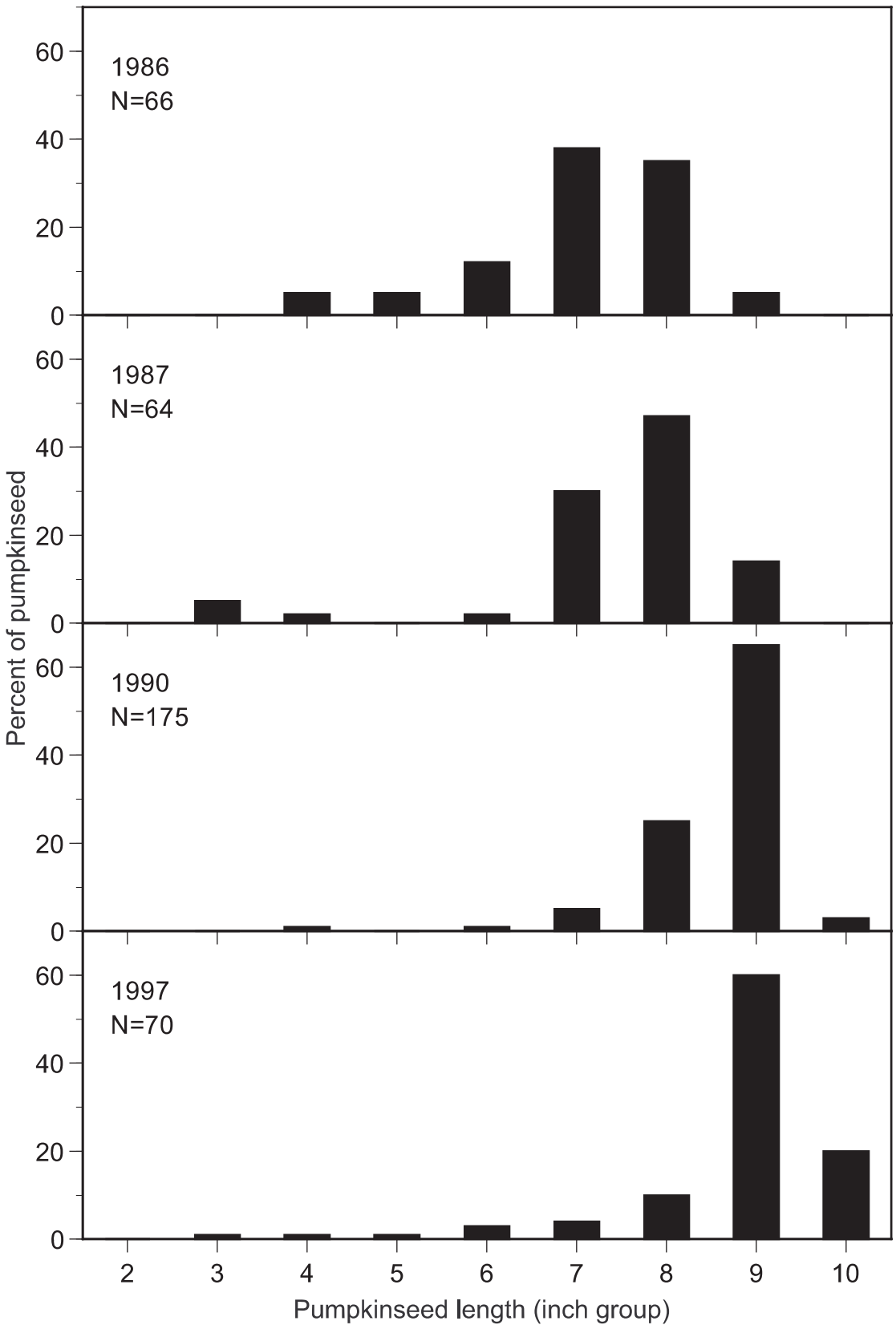

Figure 7.–Length-frequency distributions of pumpkinseed caught in large-mesh fyke nets, Wakeley Lake, 1986-97.

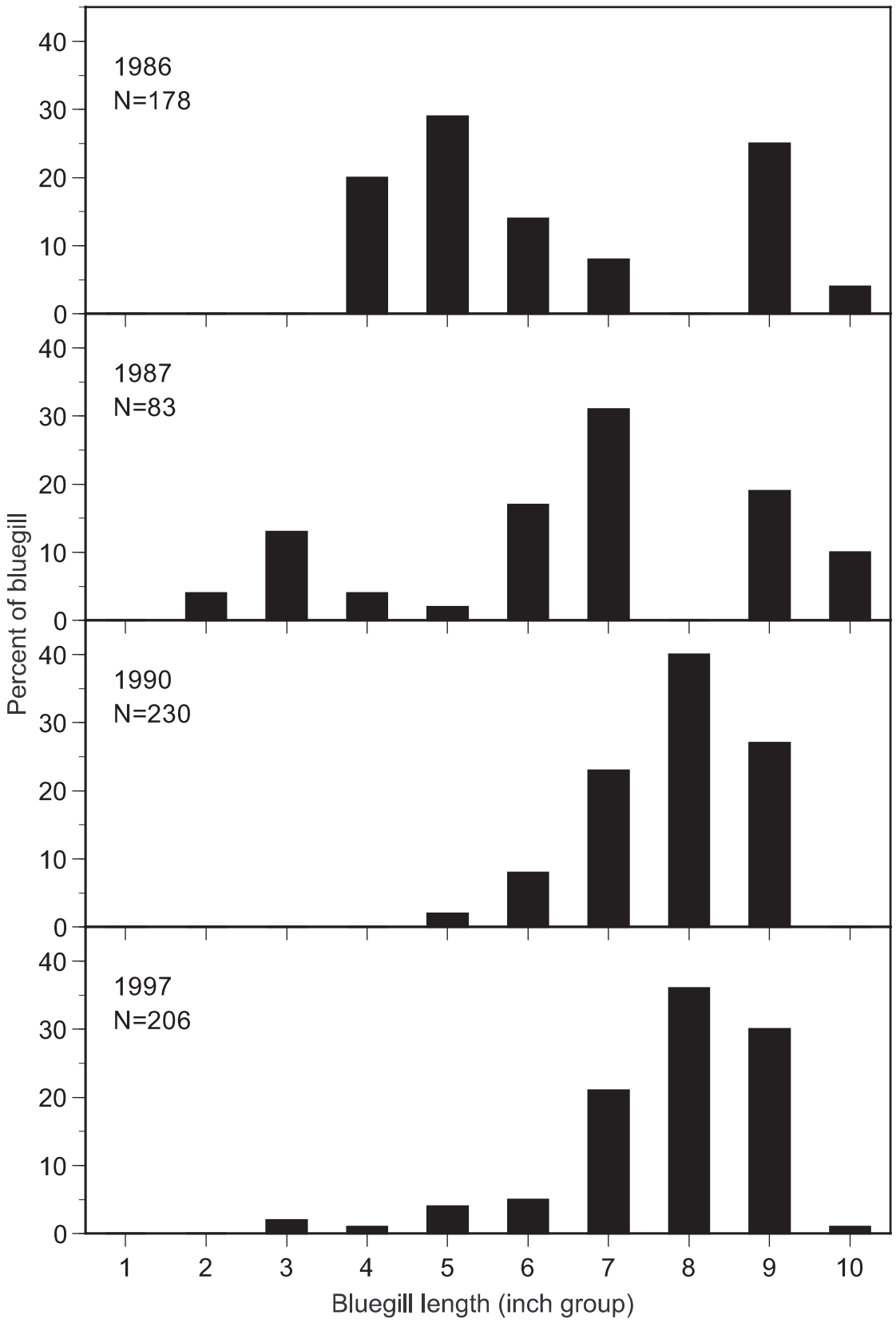

Figure 8.–Length-frequency distributions of bluegill caught in large-mesh fyke nets, Wakeley Lake, 1986-97.

Table 1.–Angler effort and catch in first week of intensive census, Wakeley Lake, 1987-97.

Statistic and year	15-Jun	16-Jun	17-Jun	18-Jun	19-Jun	20-Jun	21-Jun	Total
Day of week								
1987	Mon	Tues	Wed	Thur	Fri	Sat	Sun	
1990	Mon	Tues	Wed	Thur	Fri	Sat	Sun	
1997	Sun	Mon	Tues	Wed	Thur	Fri	Sat	
Number anglers								
1987	75	20	16	20	22	24	31	208
1990	21	29	20	8	23	17	2	120
1997	84	18	23	31	31	30	63	280
Angler hours								
1987	318	62	50	72	86	122	78	788
1990	63	91	51	25	72	70	8	381
1997	365	52	102	84	96	84	196	977
Largemouth bass catch								
1987	255	29	25	37	61	39	25	471
1990	32	35	12	2	16	18	1	116
1997	203	32	80	41	41	31	150	578
Northern pike catch								
1987	278	37	26	55	47	56	66	565
1990	8	44	7	9	19	48	4	139
1997	81	9	11	7	33	46	40	227
Sunfish catch								
1987	215	31	39	30	89	85	45	534
1990	67	120	39	0	30	38	0	294
1997	126	111	139	162	123	21	121	803
Other species								
1987	0	0	0	0	1	0	0	1
1990	0	1	0	0	0	0	0	1
1997	11	0	1	1	0	0	0	13
Largemouth bass per hour								
1987	0.80	0.47	0.50	0.52	0.71	0.32	0.32	0.60
1990	0.51	0.39	0.24	0.08	0.22	0.26	0.12	0.30
1997	0.56	0.62	0.79	0.49	0.43	0.37	0.77	0.59
Northern pike per hour								
1987	0.87	0.60	0.52	0.77	0.55	0.46	0.85	0.72
1990	0.13	0.48	0.14	0.35	0.26	0.69	0.48	0.37
1997	0.22	0.17	0.11	0.08	0.35	0.55	0.20	0.23
Sunfish per hour								
1987	0.68	0.50	0.78	0.42	1.04	0.70	0.58	0.68
1990	1.06	1.32	0.76	0.00	0.42	0.55	0.00	0.77
1997	0.35	2.14	1.37	1.94	1.29	0.25	0.62	0.82
All fish per hour								
1987	2.4	1.6	1.8	1.7	2.3	1.5	1.7	2.0
1990	1.7	2.2	1.1	0.4	0.9	1.5	0.6	1.4
1997	1.2	2.9	2.3	2.5	2.1	1.2	1.6	1.7

Table 2.–Mean and standard error (SE) for annual angler catch and effort estimates, Wakeley Lake, 1987-97.

	1987		1990		1997	
Statistic	Estimate	2SE	Estimate	2SE	Estimate	2SE
Angler trips	1,262	232	1,612	233	1,088	142
Angler hours	3,292	477	3,994	480	3,728	345
Catch						
Largemouth Bass	1,379	284	1,393	305	2,539	2,241
Northern Pike	2,326	512	752	189	668	278
Sunfish	1,288	398	4,541	1,136	1,874	791
Other species[a]	4	7	13	13	96	135
Total fish	4,997	708	6,700	1,191	5,177	2,396
Catch per hour						
Largemouth Bass	0.419	0.106	0.349	0.087	0.681	0.604
Northern Pike	0.707	0.186	0.188	0.052	0.179	0.076
Sunfish	0.391	0.134	1.137	0.316	0.503	0.217
Other species[a]	0.001	0.134	0.003	0.003	0.026	0.036
Total fish	1.518	0.308	1.678	0.360	1.389	0.655

[a]Other includes yellow perch, rock bass, bullhead, and 1 channel catfish (in 1987).

Table 3.–Summary of angler opinion questions, Wakeley Lake, 1987-97. N=number of usable interviews.

1. Fishing quality of Wakeley Lake this trip?

	First week			All data		
	1987	1990	1997	1987	1990	1997
Excellent	49%	30%	24%	39%	28%	28%
Good	35%	42%	30%	32%	38%	32%
Satisfactory	12%	21%	30%	19%	21%	25%
Poor	5%	7%	16%	10%	13%	15%
N	107	43	161	379	370	285

2. Continue catch-and-release at Wakeley Lake?

	1987	1990	1997
Yes	86%	94%	96%
No	14%	5%	3%
No opinion	4%	1%	0%
N	365	388	290

3. Would you support catch-and-release for largemouth bass, northern pike, bluegill, or trout at some other lakes? (Only "yes" responses are shown; a few % were "no opinion" and the rest were "no". The number of usable interviews varied by species.)

	1987	1990	1997
Largemouth bass	84%	91%	96%
Northern pike	72%	88%	93%
Bluegill	50%	82%	89%
Trout	65%	85%	94%
N	250-255	350-376	265-284

Table 4.–Percentage of anglers targeting various fish species, Wakeley Lake, 1987 and 1997.

Targeting	1987	1997
Northern pike	1%	1%
Largemouth bass	5%	28%
Largemouth bass and northern pike	61%	36%
Largemouth bass and panfish	4%	8%
Panfish	1%	9%
Any fish	28%	18%

Table 5.–Summary of mark-recapture population estimates of fish, Wakeley Lake, 1986-97.

Length (inch)	Year	Estimate	95% confidence limits	Recaptures <5
Largemouth bass				
10.0 - 21.9	1986	1,281	660 - 1,902	
	1987	451	313 - 580	
	1990	588	387 - 789	
	1997	927	576 - 1,278	
15.0 - 21.9	1986	55	21 - 90	
	1987	93	45 - 102	
	1990	232	150 - 313	
	1997	634	293 - 975	
Northern pike				
17.0 - 36.9	1986	1,118	0 - 2,384	1
	1987[a]	689	97 - 1,281	3
	1990[a]	1,735	219 - 3,252	
	1997	292	55 - 528	3
Bluegill				
3.0 - 5.9	1986	7,979	3,255 - 12,704	
	1987[a]	63,282	51,109 - 83,065	
	1990	69,450	27,721 - 111,179	
	1997	–	–	
6.0 - 11.9	1986	800	511 - 1,090	
	1987[b]	3,154	2,182 - 5,683	
	1990	3,309	1,077 - 5,542	
	1997	5,201	3,146 - 7,257	
Pumpkinseed				
6.0 - 10.9	1986	1,458	305 - 2,611	4
	1987[b]	631	468 - 901	
	1990	775	310 - 1,240	
	1997	1,003	519 - 1,486	
Bullheads				
5.0 - 13.9	1986	550	180 - 920	
	1987[b]	1,287	824 - 2,941	
	1990[b]	250	195 - 346	
	1997[b]	703	412 - 2,386	

[a]Recapture ratios from cooperating anglers were included in estimate.
[b]Schumacher-Eschmeyer equation was used instead of Chapman modification of the Petersen equation.

Table 6.–Growth indices (deviations in average length at age from state averages) for fish, Wakeley Lake, 1986-87. (Based on length-at-age data in Appendix 4).

Species	1986	1987	1990	1997
Largemouth bass	+1.0	+1.5	+1.3	-0.9
Northern pike	-2.0	-2.4	-2.6	-2.9
Bluegill	+0.3	+0.2	-0.8	-1.1
Pumpkinseed	+0.5	-0.1	+1.2	0.0
Yellow perch	–	-0.7	-2.2	-1.4
Rock bass	–	–	–	0.1

Table 7.–Hooking severity of fish caught by cooperating anglers at Wakeley Lake during the first week of angling, 1987-97.

		Number by species		
Year	Condition	Largemouth bass	Northern pike	Sunfish
1987	Excellent	245	246	191
	Good	25	52	13
	Poor	8	16	4
	Bad	3	10	2
Total caught		282	324	210
1990	Excellent	199	124	190
	Good	23	41	13
	Poor	3	10	6
	Bad	2	4	5
Total caught		226	179	214
1997	Excellent	63	13	114
	Good	11	7	21
	Poor	0	1	3
	Bad	0	0	0
Total caught		74	21	138
All Years	Excellent	507 (87%)	383 (73%)	496 (88%)
	Good	59 (10%)	100 (19%)	46 (8%)
	Poor	11 (2%)	27 (5%)	14 (2%)
	Bad	5 (1%)	14 (3%)	7 (1%)
Total caught		582	524	562

Table 8.–Comparison of spring mark-recapture population estimates at Wakeley Lake to adjusted catches by anglers in the same year. Fish included in the adjusted catch were made comparable in size to fish included in population estimates (largemouth bass >10 inches; northern pike >17 inches; sunfish >6 inches) by length factors.

				Adjusted catch		Adjusted catch to population estimate	
Species	Year	Population estimate	Length factor[a]	Week 1	Year	Week 1	Year
Largemouth bass	1987	451	0.98	463	1,359	103%	301%
	1990	588	0.89	104	1,244	18%	212%
	1997	927	0.93	539	2,369	58%	256%
Northern pike	1987	689	0.87	490	2,019	71%	293%
	1990	1,735	0.80	111	603	6%	35%
	1997	292	0.85	193	568	66%	194%
Sunfish	1987	3,785	0.55	294	710	8%	19%
	1990	4,084	0.74	219	3,383	5%	83%
	1997	6,204	0.71	569	1,327	9%	21%

[a]Fraction of angler's catch exceeding the minimum length for the population estimate.

Table 9.–Trends in fishing statistics at three lakes in the Rifle River Area after opening to the public: 1945 (first year) compared to 1946-56 averages (from Patriarche 1960). Small italic indicates <12 fish in catch and less reliable estimates of change; a (–) indicates species was not present in lake; change = (((1946-56 average) – 1945 data) / 1945 data) * 100.

	Devoe (130 acres)			Dollar (12.9 acres)			North (95 acres)			Average
Statistic	1945	46-56	Change	1945	46-56	Change	1945	46-56	Change	change
Hrs/acre	44.6	24.2	-46%	144.4	86.4	-40%	17.9	10.5	-41%	-42%
Total lbs/ac	6.23	3.08	-51%	1068	344	-68%	3.90	1.26	-68%	-62%
Total lbs/ac-hr	0.14	0.13	-7%	7.40	3.98	-46%	0.22	0.12	-45%	-33%
Total fish/ac	5.81	9.45	63%	372	142	-62%	6.35	2.50	-61%	-20%
Total fish/ac-hr	0.13	0.39	200%	2.58	1.64	-36%	0.36	0.24	-33%	43%
Total catch/hr	0.13	0.37	185%	2.58	1.70	-34%	0.36	0.23	-36%	38%
Hourly catch per acre										
Largemouth bass	0.54	0.11	-80%	7.67	3.21	-58%	0.80	0.13	-84%	-74%
Smallmouth bass	0.68	0.39	-43%	–	–	–	0.53	0.27	-49%	-46%
Northern pike	0.52	0.05	-90%	–	–	–	0.02	0.03	50%	-20%
Bluegill	0.71	0.41	-42%	208.4	99.53	-52%	0.69	0.11	-84%	-60%
Pumpkinseed	0.37	0.11	-70%	78.53	10.68	-86%	0.13	0.01	-92%	-83%
Yellow perch	1.65	6.12	271%	24.42	11.29	-54%	3.85	1.58	-59%	53%
Rock bass	0.95	0.76	-20%	3.18	3.74	18%	0.23	0.31	35%	11%
Black crappie	0.02	0.17	750%	46.12	8.66	-81%	–	–	–	–
Catch per hour										
Largemouth bass	0.012	0.005	-58%	0.053	0.037	-30%	0.045	0.012	-73%	-54%
Smallmouth bass	0.015	0.016	7%	–	–	–	0.029	0.026	-10%	-1%
Northern pike	0.012	0.002	-83%	–	–	–	0.001	0.003	200%	–
Bluegill	0.016	0.017	6%	1.443	1.152	-20%	0.039	0.011	-72%	-29%
Pumpkinseed	0.008	0.005	-38%	0.544	0.124	-77%	0.007	0.001	-86%	-67%
Yellow perch	0.037	0.253	584%	0.169	0.131	-22%	0.215	0.150	-30%	177%
Rock bass	0.021	0.031	48%	0.022	0.043	95%	0.013	0.029	123%	89%
Black crappie	0.000	0.007	++	0.319	0.100	-69%	–	–	–	–

Table 10.–Relationship between rank of fishing trip quality and catch rate per angler by targeted fish, Wakeley Lake, 1987-97.

Catch/hr targeted fish	Number interviews	Quality of trip			
		Poor	Satisfactory/good	Excellent	Total
Bass and northern pike					
0.0-0.4	67	40%	51%	9%	100%
0.5-0.9	42	7%	62%	31%	100%
1.0-1.9	42	2%	64%	33%	100%
2.0-2.9	14	7%	50%	43%	100%
3.0-3.9	3	0%	33%	67%	100%
5.0-5.9	1	0%	0%	100%	100%
Average/hr		0.24	0.89[a]	1.36	
Any fish or panfish					
0.0-0.4	17	41%	47%	12%	100%
0.5-0.9	13	8%	69%	23%	100%
1.0-1.9	16	13%	88%	0%	100%
2.0-2.9	11	0%	73%	27%	100%
3.0-3.9	7	0%	43%	57%	100%
4.0-4.9	10	0%	50%	50%	100%
5.0-5.9	5	0%	60%	40%	100%
6.0-6.9	3	0%	67%	33%	100%
7.0+	7	0%	0%	100%	100%
Average/hr		0.51	2.00[b]	5.10	

[a]Average CPH for satisfactory and good groups were identical.

[b]Average catch rate for satisfactory group was 1.96 fish/hour; for good group 2.00 fish per hour.

Table 11.–Comparative densities of largemouth bass in unexploited and exploited Michigan lakes exceeding indicated minimum sizes, as estimated by mark-and-recapture methods. Lakes are arranged from south to north.

Lake	County	Minimum length (in)	Number per acre	Reference
		Unexploited		
Third Sister	Washtenaw	≥10	12	Schneider 1971
Mill	Washtenaw	≥10	9.4	Schneider 1971
		≥15	1.0-1.4	Schneider 1971
Dead	Washtenaw	≥10	6.6	Schneider 1993
		≥14	1.9	Schneider 1993
Blueberry	Livingston	≥10	27	Schneider 1993
		≥14	1.6	Schneider 1993
Wakeley	Crawford	≥10	2.7-7.6	This study
		≥15	0.3-3.8	This study
Cub	Gogebic	≥10	25	Clady 1975
		≥15	0	Clady 1975
		Exploited		
Whitmore	Washtenaw	≥10	3.1-8.1	Latta 1959; Goudy 1981
Sugarloaf	Washtenaw	≥10	2.0-9.5	Laarman and Schneider 1979
Pontiac	Oakland	≥10	4.9	Goudy 1981
Kent	Oakland	≥10	1.5	Goudy 1981
Lodge	Ogemaw	≥10	1	Schneider 1971
Jewett	Ogemaw	≥10	10.5	Schneider 1995
		≥14	2.3	Schneider 1995
Fife	Grand Traverse	≥10	3.0-5.5	Schneider 1971
Stager	Iron	≥12	0.4	Wagner 1988
Tepee	Iron	≥12	0.8	Wagner 1988
Chicago	Delta	≥12	0.2	Wagner 1988
East	Schoolcraft	≥12	1.1	Wagner 1988
Anderson	Marquette	≥12	0.6	Wagner 1988
Big Shag	Marquette	≥12	0.6	Wagner 1988

Table 12.–Comparative densities of northern pike in unexploited and exploited Michigan lakes exceeding indicated minimum sizes, as estimated by mark-and-recapture methods. Lakes are arranged by decreasing latitude.

Lake	County	Minimum length (in)	Number per acre	Reference
		Unexploited		
Mill	Washtenaw	≥20	1.2	Schneider 1971
Dead	Washtenaw	≥20	2.6	Schneider 1993
Wakeley	Crawford	≥17	1.7-10.3	This study
		Exploited		
Sugarloaf	Washtenaw	≥14	0.4-5.1	Laarman and Schneider 1979
Whitmore	Washtenaw	≥14	0.8	Schneider 1971
Big Portage	Jackson	≥14	0.6	Schneider 1971
Fife	Grand Traverse	≥14	6.4	Schneider 1971
Grebe	Ogemaw	≥13	10	Schneider 1971
		≥20	5	Schneider 1971
Manistee	Kalkaska	≥20	0.4-2.2	Laarman and Schneider 1986

Table 13.–Michigan lakes being managed in 1999 with catch-and-release (C-R) or other very restrictive regulations for coolwater and warmwater fishes. Lakes are arranged by decreasing latitude.

Lake	County	Special regulations (possession and size limits, lures)
Williams	Barry	C-R; artificial lures; April 1-Dec. 15
Horseshoe	Washtenaw	1 bass >14”; 1 pike >24”; 10 panfish
Algoe	Lapeer	C-R; artificial lures
Big Cranberry	Clare	C-R; artificial lures
Wakeley	Crawford	C-R; artificial lures; June 15-Aug. 31
N. & S. Blue, Robarge	Montmorency	C-R; artificial lures; Apr. 1-Sept. 30
North Manitou	Leelenau	1 bass>18”
Duck and Echo	Alger	C-R bass; 1 pike>30”; total <5 fish; artificial lures
Craig Lakes (7 lakes)	Baraga	C-R bass, pike, musky; 2 walleye>13”; artificial lures
Sylvania Tract (32 lakes)	Gogebic	C-R bass; 1 pike>30”; 1 lake trout>30”; 1 walleye>20”; 10 of other spp; artificial lures
Twin	Luce	1 bass>18”
Deer Lake Basin	Marquette	C-R; artificial lures
Fish Lake	Marquette	1 bass>18”; 5 pike>30”
Big Island Complex (8 lakes)	Schoolcraft	1 bass >18”; 1 pike>42”; 5 panfish; artificial lures

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Appendix 1.–Angler interview form used at Wakeley Lake in 1997. Similar forms were used in 1987 and 1990.

Wakeley Lake Random Creel Census-- June 15-August 31, 1997

Interview by: _____

Date: _____ **Day:** _____ (1=Mon, 2=Tues, 3=Wed, 4=Thur, 5=Fri, 6=Sat, 7=Sun, 8=holiday)

Start time: _____ **End time:** _____ **Hours fished:** _____

Military: **01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24**
am/pm: 1 2 3 4 5 6 7 8 9 10 11 noon 1 2 3 4 5 6 7 8 9 10 11 midnight

Mode of Fishing: boat shore tube **Completed trip:** yes no

Trip/day: _____ **Sex:** _____ **Res. ZIP:** _____ **Res. State:** _____

Methods: cast fly cast troll/drift still

Target sp: anything bass pike bass/pike panfish

Number caught: Bass: _____ Bluegill: _____ Other: _____
Pike: _____ P'seed: _____

Rank today's fishing quality: excellent good satisfact. poor no opinion

Continue these regulations?: yes no

Catch/release other lakes?: Bass: yes no **Want to make comments?**
Pike: yes no
Trout: yes no
Bluegill: yes no

Wakeley Lake Random Creel Census-- June 15-August 31, 1997

Interview by: _____

Date: _____ **Day:** _____ (1=Mon, 2=Tues, 3=Wed, 4=Thur, 5=Fri, 6=Sat, 7=Sun, 8=holiday)

Start time: _____ **End time:** _____ **Hours fished:** _____

Military: **01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24**
am/pm: 1 2 3 4 5 6 7 8 9 10 11 noon 1 2 3 4 5 6 7 8 9 10 11 midnight

Mode of Fishing: boat shore tube **Completed trip:** yes no

Trip/day: _____ **Sex:** _____ **Res. ZIP:** _____ **Res. State:** _____

Methods: cast fly cast troll/drift still

Target sp: anything bass pike bass/pike panfish

Number caught: Bass: _____ Bluegill: _____ Other: _____
Pike: _____ P'seed: _____

Rank today's fishing quality: excellent good satisfact. poor no opinion

Continue these regulations?: yes no

Catch/release other lakes?: Bass: yes no **Want to make comments?**
Pike: yes no
Trout: yes no
Bluegill: yes no

Appendix 2.–Length-frequency distributions (%) of fish caught by fyke nets and electrofishing, by species, Wakeley Lake, 1986-97. N is total number of fish sampled. For each species, each column total is 100%.

Species	Inch group	Largemesh fyke (2" str.)				Smallmesh fyke (3/4" str.)				Electrofishing		
		1986	1987	1990	1997	1986	1987	1990	1997	1987	1990	1997
Largemouth bass	1	0	0	0	0	4	0	0	0	0	0	0
	2	0	0	0	0	0	6	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	6	0	0
	4	0	0	0	0	0	0	5	0	9	4	0
	5	0	0	0	0	0	0	0	0	3	5	0
	6	0	0	0	0	0	0	0	0	1	2	2
	7	2	0	0	0	0	0	0	0	0	4	10
	8	1	0	1	0	0	0	0	0	2	4	11
	9	0	0	0	0	0	0	2	0	6	5	4
	10	3	1	2	1	4	6	1	0	8	6	6
	11	8	2	4	0	17	0	2	0	3	6	7
	12	26	12	15	2	29	6	16	3	13	13	4
	13	37	26	13	13	26	21	6	7	18	11	7
	14	12	35	17	24	9	11	13	13	16	9	12
	15	2	11	20	18	9	17	26	23	5	11	13
	16	4	3	19	22	0	11	13	34	2	12	13
	17	2	4	4	15	0	11	4	17	4	5	7
	18	1	3	2	2	0	11	7	3	1	1	1
	19	1	1	1	3	0	0	1	0	2	0	1
	20	1	1	1	0	0	0	0	0	1	0	0
	21	0	1	1	0	0	0	0	0	0	0	0
	N	129	90	133	101	23	18	82	30	192	114	257
Bluegill	1	0	0	0	0	0	0	0	0	1	0	0
	2	0	4	0	0	17	16	20	4	8	15	0
	3	0	13	0	2	12	46	61	13	30	41	5
	4	20	4	0	1	47	22	6	6	31	18	21
	5	29	2	2	4	14	8	2	13	18	9	19
	6	14	17	8	5	7	3	1	10	9	5	11
	7	8	31	23	21	1	2	2	11	3	6	11
	8	0	0	40	36	0	0	6	21	0	4	18
	9	25	19	27	30	2	2	2	21	0	2	15
	10	4	10	0	1	0	1	0	1	0	0	0
	N	178	83	230	206	473	599	826	201	1538	571	687
Pumpkinseed	2	0	0	0	0	9	18	3	0	3	1	0
	3	0	5	0	1	15	22	7	0	16	8	2
	4	5	2	1	1	12	6	6	4	15	2	12
	5	5	0	0	1	4	5	1	0	8	11	10
	6	12	2	1	3	26	5	2	4	9	13	8
	7	38	30	5	4	26	23	3	2	29	16	8
	8	35	47	25	10	8	20	15	18	18	30	18
	9	5	14	65	60	0	1	63	57	2	19	39
	10	0	0	3	20	0	0	1	15	0	0	3
	N	66	64	175	70	93	105	123	55	292	85	153

Appendix 2.–continued.

Species	Inch group	Largemesh fyke (2" str.)				Smallmesh fyke (3/4" str.)				Electrofishing		
		1986	1987	1990	1997	1986	1987	1990	1997	1987	1990	1997
Bullhead spp	2	0	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	4	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	7	0	0
	6	0	0	0	2	0	0	0	2	3	0	0
	7	0	1	0	0	4	0	1	2	3	0	8
	8	12	1	1	0	18	3	1	5	16	0	3
	9	42	7	2	5	32	15	5	9	19	6	0
	10	22	26	27	21	31	28	23	27	28	31	25
	11	20	52	44	16	11	44	46	23	23	32	19
	12	2	11	26	40	0	10	23	23	1	31	28
	13	0	2	0	16	0	0	1	9	0	0	17
	N	41	123	219	56	28	231	146	56	73	16	36
Northern pike	6	0	0	0	0	0	0	0	7	1	0	0
	7	0	0	0	0	0	0	0	0	3	0	11
	8	0	0	0	0	0	0	0	0	4	0	0
	9	0	0	0	0	0	0	8	0	3	0	0
	10	0	0	0	0	0	0	8	0	6	0	0
	11	0	0	1	0	0	0	0	7	0	0	11
	12	0	0	0	0	0	0	0	7	6	11	11
	13	0	0	0	0	0	0	8	0	6	0	11
	14	0	0	1	2	0	0	0	7	4	0	0
	15	2	0	1	0	50	0	8	0	1	0	11
	16	5	2	0	4	0	0	17	7	4	11	0
	17	2	5	7	2	0	15	0	0	3	22	0
	18	10	5	6	2	0	8	0	0	3	23	0
	19	7	5	7	9	0	0	0	0	9	0	0
	20	17	12	11	9	0	0	0	14	10	22	0
	21	26	21	25	9	0	31	17	0	12	0	11
	22	17	9	24	25	0	8	26	23	10	11	11
	23	7	14	6	9	0	15	8	0	9	0	0
	24	5	12	6	13	0	23	0	14	0	0	23
	25	0	2	3	4	0	0	0	7	1	0	0
	26	0	2	0	2	0	0	0	7	3	0	0
	27	0	0	0	2	0	0	0	0	1	0	0
	28	0	5	1	0	0	0	0	0	0	0	0
	29	2	0	0	0	50	0	0	0	0	0	0
	30	0	2	0	2	0	0	0	0	1	0	0
	31	0	0	0	0	0	0	0	0	0	0	0
	32	0	0	0	2	0	0	0	0	0	0	0
	33	0	2	1	4	0	0	0	0	0	0	0
	34	0	0	0	0	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0	0	0	0	0
	36	0	2	0	0	0	0	0	0	0	0	0
	N	42	43	70	46	2	13	12	14	78	9	9

Appendix 3.–Size-frequency of fish caught (%), as measured by cooperating anglers at Wakeley Lake, during the first week of the season (June 15-21) in 1987, 1990, and 1997.

Inch	Largemouth bass			Northern pike			All sunfish		
group	1987	1990	1997	1987	1990	1997	1987	1990	1997
N	343	243	75	402	202	20	316	216	144
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	1
3	0	0	0	0	0	0	1	5	1
4	0	1	0	0	0	0	23	9	15
5	0	0	0	0	0	0	21	11	13
6	0	1	0	0	0	0	12	21	13
7	0	2	0	0	0	0	20	21	14
8	1	3	1	0	0	0	15	14	18
9	1	4	5	0	0	0	7	14	23
10	5	7	9	0	1	5	2	4	2
11	3	5	4	0	0	0	0	0	0
12	10	11	12	2	3	0	0	0	0
13	24	10	4	1	1	0	0	0	0
14	29	17	4	1	2	0	0	0	0
15	12	15	11	3	4	10	0	0	0
16	8	15	17	5	8	0	0	0	0
17	4	6	12	8	2	5	0	0	0
18	1	2	16	10	17	20	0	0	0
19	1	1	3	12	8	0	0	0	0
20	1	0	1	17	16	15	0	0	0
21	0	0	0	13	14	5	0	0	0
22	0	0	1	14	13	10	0	0	0
23	0	0	0	5	5	10	0	0	0
24	0	0	0	5	4	0	0	0	0
25	0	0	0	3	2	5	0	0	0
26	0	0	0	1	0	10	0	0	0
27	0	0	0	0	0	5	0	0	0
Total	100	100	100	100	100	100	100	100	100

Appendix 4.–Average length at age (inches) of fish and number of fish sampled by age group, Wakeley Lake, 1986-97.

	July 1986		May-June 1987		May-June 1990		May-June 1997	
Age	Length	Number	Length	Number	Length	Number	Length	Number
				Largemouth bass				
1	–	–	4.6	21	5.4	4	–	–
2	8.5	10	7.5	2	8.9	15	6.4	6
3	11.4	30	10.0	27	12.1	42	8.2	34
4	13.0	99	13.5	106	13.8	23	10.6	31
5	15.5	7	15.7	19	15.7	36	12.8	16
6	16.5	7	16.8	9	16.5	27	14.5	36
7	17.6	9	18.0	3	17.5	9	16.1	30
8	18.5	2	19.1	6	18.6	1	17.4	10
9	20.7	3	–	–	–	–	18.1	1
10	21.2	1	20.3	1	–	–	19.1	6
11	–	–	–	–	–	–	20.0	2
				Northern pike				
1	–	–	9.6	12	10.7	4	6.8	2
2	16.8	11	14.2	10	18.0	15	13.0	7
3	20.1	26	18.1	21	19.2	17	18.1	11
4	22.1	46	21.8	54	21.8	14	21.6	18
5	25.2	1	23.5	19	22.8	17	23.5	17
6	–	–	27.7	4	23.9	7	24.9	7
7	29.5	2	30.3	1	23.1	1	25.5	3
8	32.5	1	–	–	–	–	33.1	3
9	–	–	36.4	1	33.2	1	–	–
				Bluegill				
1	–	–	–	–	2.5	5	–	–
2	2.7	14	2.5	7	2.8	1	2.4	10
3	4.4	26	3.2	23	3.6	20	3.2	8
4	6.8	26	4.9	40	4.2	6	3.9	25
5	9.8	23	7.1	46	6.1	14	5.7	3
6	–	–	9.7	23	7.4	53	5.4	19
7	–	–	10.1	9	9	13	6.2	17
8	–	–	11.0	1	–	–	7.4	12
9	–	–	–	–	–	–	8.4	23
10	–	–	–	–	–	–	8.7	17
11	–	–	–	–	–	–	9.8	7
				Yellow perch				
1	–	–	2.8	13	2.9	3	–	–
2	–	–	4.6	6	3.5	7	4.1	3
3	–	–	5.6	6	4.6	2	5.4	24
4	–	–	6.2	1	6.2	2	–	–
5	–	–	–	–	–	–	–	–
6	–	–	8.7	2	–	–	–	–

Appendix 4.–continued.

Age	July 1986		May-June 1987		May-June 1990		May-June 1997	
	Length	Number	Length	Number	Length	Number	Length	Number
				Pumpkinseed				
1	–	–	–	–	2.7	3	–	–
2	3.0	17	2.4	17	3.4	3	3.0	1
3	4.6	18	3.4	23	4.6	4	3.7	5
4	7.3	24	4.9	20	5.1	4	5.0	24
5	8.7	9	7.1	59	6.8	7	6.1	3
6	8.4	1	8.8	27	7.9	31	7.3	15
7	–	–	–	–	9.3	28	7.8	16
8	–	–	–	–	9.5	4	8.6	7
9	–	–	–	–	–	–	9.4	8
10	–	–	–	–	–	–	9.8	13
11	–	–	–	–	–	–	9.5	10
12	–	–	–	–	–	–	9.9	4
				Rock bass				
2	–	–	–	–	3.7	1	–	–
3	–	–	6.2	1	5.3	1	–	–
4	–	–	–	–	–	–	6.7	5
5	–	–	9.1	3			7.7	1
6	–	–	9.8	1	9.9	2	8.5	1
7	–	–	–	–	–	–	9.3	15
8	–	–	–	–	–	–	8.8	6
9	–	–	–	–	–	–	9.7	6