Relations among Angler Use, Harvest, and Stocking Rates of Channel Catfish in Missouri Impoundments

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Abstract: We examined relations among creel statistics and stocking rates of channel catfish (*Ictalurus punctatus*) in small impoundments. Angling effort directed toward catfish varied from 2 to 790 hours ha^{-1} and made up between 1% and 62% of the total angling effort. Anglers harvested nearly all of the channel catfish they caught in most impoundments. Harvest of channel catfish varied from 0.4 to 126 fish ha^{-1} and 0.3 to 74 kg ha^{-1} and was more closely associated with catfish angling effort than with stocking rate. Harvest rate declined asymptotically with increasing catfish angling effort. Catfish angling effort slightly increased and mean size of harvested channel catfish slightly decreased with increasing stocking rate. Stocking rate had a small influence on creel statistics compared to angling effort.

Key words: channel catfish, creel, angler use, stocking

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Channel catfish (*Ictalurus punctatus*) provides popular sport fisheries in many small impoundments (hereafter termed lakes) throughout the Midwestern and southern United States (Michaletz and Dillard 1999). For example in Missouri, catfish anglers accounted for 21% of the total angling effort in small public lakes in Missouri, second only to black bass (*Micropterus* spp.) anglers (Weithman 1991). Considerable financial and human resources are invested in stockings of large channel catfish fingerlings into these lakes (Michaletz and Dillard 1999), which are necessary because largemouth bass (*M. salmoides*) predation commonly eliminates natural recruitment (Marzolf 1957, Krummrich and Heidinger 1973, Storck and Newman 1988).

Few evaluations of angler use and harvest of channel catfish in small lakes have been reported in the peer-reviewed literature, despite the relatively high maintenance costs and widespread popularity of these fisheries. Among these evaluations, daytime angling effort directed toward channel catfish ranged from 22 to 1,969 hours ha^{-1} (Mosher 1983, Eder and McDannold 1987, Parrett et al. 1999) and harvest of channel catfish ranged from 0 to 768 fish ha^{-1} and 0 to 359 kg ha^{-1} (Powell 1976,

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Mosher 1983, Eder and McDannold 1987, Shaner et al. 1996, Parrett et al. 1999). Part of this variability in angling effort and channel catfish harvest may be related to the number and sizes of channel catfish stocked (Storck and Newman 1988, Shaner et al. 1996). Shaner et al. (1996) found that catfish harvest was positively related to the number and biomass of catfish stocked in public fishing lakes in Alabama.

We summarized available creel survey data for put-grow-take channel catfish fisheries in small public lakes in Missouri. Our objective was to determine relationships among angling effort, catch, harvest, and stocking rates of channel catfish. This information should prove useful in determining appropriate stocking rates and management strategies for channel catfish fisheries in small lakes.

Methods

Creel

Channel catfish creel data were acquired for 27 small lakes (1–178 ha) managed for put-grow-take fisheries. These lakes were scattered across much of the state. Most lakes were regulated with a four catfish daily creel limit and fishing was restricted to pole-and-line only (i.e., prohibiting trot or limb lines, jugs, etc.). One lake had a 381-mm total length (TL) minimum size limit on channel catfish during its two creel years. Eleven of the lakes were closed to fishing at night (most closed between 2200 to 0400 hours or to 0600 hours), while others were open 24 hours a day.

Creel survey data were collected during 1 to 37 years in each lake during 1956 to 1998. Standardization of creel survey procedures and analysis allowed us to compare survey data collected over a broad time period (Stanovick and Haverland 1997). Prior to the mid 1970s, most creel surveys did not partition angling effort among various fish species so effort, catch rates, and harvest rates specific to catfish anglers were not available from all creel surveys. Catfish effort also included effort directed toward blue catfish (*Ictalurus furcatus*) and flathead catfish (*Pylodictis olivaris*), but these species were either absent or in low abundance in the lakes. Some other creel statistics were also not available from all creel surveys.

Daytime roving or access point creel surveys were conducted from March/April to September/October. All survey statistics were calculated monthly for roving surveys. Weekend days and weekdays were stratified and 4–6 weekend days and 8–12 weekdays were sampled per month. Time periods within a survey day were 2–6 hours in length. Two instantaneous counts of all boat and bank anglers on the lake were randomly taken within each survey period. Access point surveys collected weekly or monthly estimates depending on the individual survey. All sampling days, time periods within days, and sampling sites were selected using non-uniform probability sampling. Five days were sampled per week for surveys where weekly estimates were generated, and between 12–16 days were sampled per month for surveys where monthly samples were generated. Weekend days were usually probability weighted twice what weekdays were weighted. Access points were probability weighted based on prior use estimates or subjective judgments of biologists and wardens. A morning or afternoon shift was conducted within each sampling day to limit the number of hours worked by a creel clerk. Morning and afternoon shifts were probability weighted and probabilities were adjusted seasonally to pick up differences in angling pressure. Probabilities were adjusted because angling pressure varies throughout the sampling day, and these diurnal variations change throughout the creel season. For example, anglers fish more in the middle of the day in the spring and fall than they do in the hot summer months; when fishing is concentrated in early morning and evening hours. Weighting of the shifts was based on past survey results or observations made by local biologists and wardens. For both survey methodologies, time periods were adjusted so that samples would be conducted between sunrise and sunset. Monthly or weekly estimates were summed to get a seasonal total (spring–fall) for each statistic for each year.

A limitation of using these creel data was that they were derived from surveys conducted during daylight hours and thus did not account for nighttime fishing which may be important for channel catfish. Indeed, Parrett et al. (1999) found that over 50% of the channel catfish harvest and catfish angling effort occurred at night in two Ohio impoundments. However, Eder and McDannold (1987) found that nighttime fishing accounted for only about 17% of the channel catfish harvest and 19% of catfish angling effort in Pony Express Lake, Missouri. While channel catfish harvest and angling effort were undoubtedly underestimated from daytime-only creels, our analyses of relationships among angling effort, creel statistics, and stocking are probably not seriously biased. Over half (107 of 193 lake–years) of the creel estimates we used were taken from lakes that were closed to night fishing. Creel data from these lakes covered the range of data found among all of the study lakes and the highest estimates of channel catfish angling effort and harvest were derived from these lakes. Using analyses of covariance, we found no differences (all $P > 0.43$) in the relationships among channel catfish angling effort, harvest, and stocking rates (see below) between those lakes closed to night fishing and the other lakes.

Stocking

A channel catfish stocking rate index was developed for each lake/year combination to compare with the creel statistics. This index could only be calculated for 24 small lakes because of missing or censored (see below) data. The stocking rate index (SI) for year i was calculated as:

$$SI_i = 0.50s_{i-1} + 0.25s_{i-2} + 0.125s_{i-3}$$

where s equals the number of channel catfish fingerlings stocked ha^{-1} (Hanson 1986). This index combines stockings for the three previous years assuming a 50% annual mortality rate. We computed this index because stocking rates frequently varied annually within a lake and angler catch and harvest would by influenced by more than just the latest stocking. While mortality rates certainly vary among lakes, the 50% mortality rate that we used falls in the middle of the range of estimated annual mortality rates (13% to 88%) summarized by Hubert (1999). The study lakes were stocked in the fall (late September or October) with large (mean TL = 178 to

330 mm) channel catfish fingerlings at rates of 0 to 317 fingerlings ha^{-1}. The average stocking rate (excluding years when lakes were not stocked) was 56 fingerlings ha^{-1} during the study period. Typical annual stocking rates for put-grow-take fisheries in Missouri were reduced from about 74–124 fingerlings ha^{-1} in the 1960s and 1970s to about 25–49 fingerlings ha^{-1} 1980s and 1990s in an attempt to improve channel catfish growth rates and size structure (Eder et al. 1997). We did not compute the stocking rate index when stockings during one or more years consisted of smaller (< 150 mm mean TL) fingerlings because these fingerling probably experienced high mortality due to predation by largemouth bass and other predators (Krummrich and Heidinger 1973, Storck and Newman 1988).

Statistical Analysis

Simple and stepwise linear regression analyses were used to examine relations among creel statistics and the stocking rate index. Stepwise regressions were used to assess the relative importance of angling effort and the stocking rate index in accounting for variation in harvest statistics using $P \leqq 0.10$ as variable entrance and exit criteria. A variety of methods were used to determine the appropriateness of regression models including residual plots, tests for multicollinearity, and influence statistics (SAS 2003). When necessary, variables were $\log_e$-transformed in order to linearize relationships. Additionally, a two-dimensional Kolmogorov-Smirnov (2DKS) test (Garvey et al. 1998) was used to examine the relationship between catfish angling effort and harvest rate. Statistical tests were considered significant at $P \leqq 0.05$.

Results

Creel statistics varied greatly among small lakes and years (Table 1). Total angling effort ranged from 70 to 3,133 hours ha^{-1} and effort directed toward catfish ranged from 2 to 790 hours ha^{-1}. The importance of catfish to sport fisheries differed widely with effort directed toward catfish making up from less than 1% to 62% of the total angling effort. Catch and harvest in numbers of channel catfish ranged from

Table 1. Creel statistics for small lakes in Missouri. N = number of lake-year combinations.

Variable	Mean(SE)	Minimum	Maximum	N
Total angling effort (hours ha^{-1})	731(32)	70	3133	193
Catfish angling effort (hours ha^{-1})	183(12)	2	790	152
Catfish angling effort (% of total)	26(1)	0.3	62	152
Catfish catch (N ha^{-1})	30(2)	1	148	113
Catfish harvest (N ha^{-1})	30(2)	0.4	126	193
Catfish harvest (% of catch)	89(1)	33	100	113
Catfish harvest (kg ha^{-1})	14(1)	0.3	74	183
Catfish catch rate (N h^{-1})	0.24(0.02)	0.01	1.43	109
Catfish harvest rate (N h^{-1})	0.21(0.01)	0.01	0.91	152

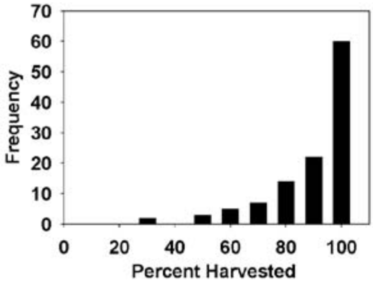

Figure 1. Frequency distribution of the percent of angler-caught channel catfish that were harvested. Each observation represents the percent harvested for a lake-year combination.

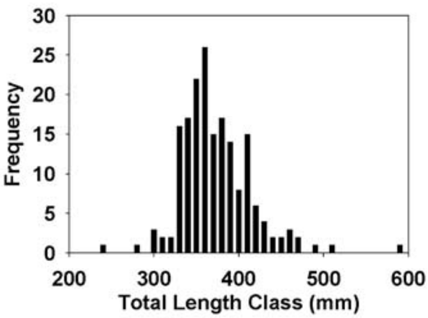

Figure 2. Frequency distribution of the mean total length (mm) of channel catfish harvested by anglers. Each observation represents the mean for a lake-year combination.

≤1 to over 100 fish ha^{-1}. Harvest in weight varied from 0.3 to 74 kg ha^{-1}. Catch and harvest rates of channel catfish varied from 0.01 to about 1 fish h^{-1}. Most channel catfish caught by anglers were harvested but as few as 33% were harvested during two years in the lake with a minimum size limit (Table 1, Fig. 1). Because catch and harvest ($r = 0.97$, $P < 0.001$, $N = 113$) and catch rate and harvest rate ($r = 0.94$, $P < 0.001$, $N = 109$) were strongly correlated, we report only harvest statistics hereafter. Mean TL of channel catfish harvested ranged from 236 to 589 mm among lake-year combinations (Fig. 2).

Harvest in numbers and weight of channel catfish increased with angling effort and stocking rate. While harvest in numbers ($r^2 = 0.42$, $P < 0.0001$, $N = 193$) and weight ($r^2 = 0.40$, $P < 0.0001$, $N = 183$) were significantly related to total angling effort, more of their variation was explained by catfish angling effort (Fig. 3). Harvest in numbers and weight were weakly but significantly related to the stocking rate index (Fig. 3). However when using stepwise regression, the stocking rate index was not included ($P > 0.13$) in models explaining variation in harvest (numbers and weight) after including catfish angling effort.

Harvest rate declined asymptotically with increasing catfish angling ef-

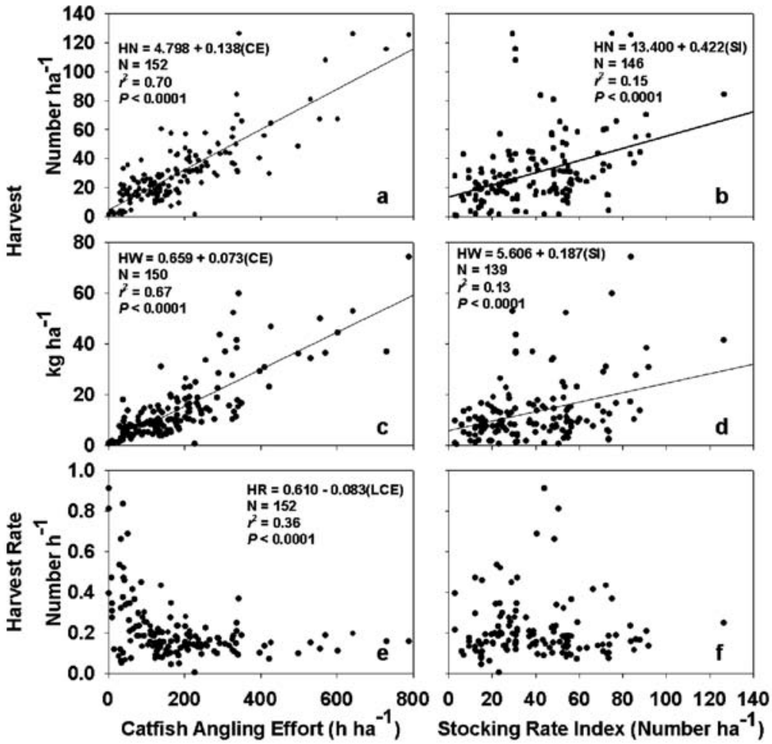

Figure 3. Scatter plots showing the relationships between channel catfish harvest (HN, numbers ha^{-1}) and catfish angling effort (CE, h ha^{-1}, panel a), harvest (HW, kg ha^{-1}) and CE (panel c), harvest rate (HR, number h^{-1}) and CE (panel e), HN and the stocking rate index (SI, panel b), HW and SI (panel d), and HR and SI (panel f). LCE (shown in panel e) indicates $\log_e$-transformed catfish angling effort. No line was drawn in panel e because the regression was based on log-transformed data.

fort (Figure 3) but was not significantly related to stocking rate (P = 0.71 Fig. 3). About one–third of the variation (36%) in harvest rate was explained by the $\log_e$-transformed catfish angling effort. Although significant (P < 0.001), untransformed catfish angling effort explained only 13% of the variation in harvest rate. We also found a significant relationship between catfish angling effort and harvest rate using the 2DKS test (D_{BKS} = 0.12; P = 0.0002). This test revealed that below about 102 hours ha^{-1} of catfish angling effort harvest rate was highly variable. Above this level of angling effort, harvest rate was usually below 0.2 fish h^{-1}. While harvest rate (HR) was unrelated to the stocking rate index alone, a small (2%) but significant (P = 0.023) proportion of the variation in harvest rate was explained by the stocking

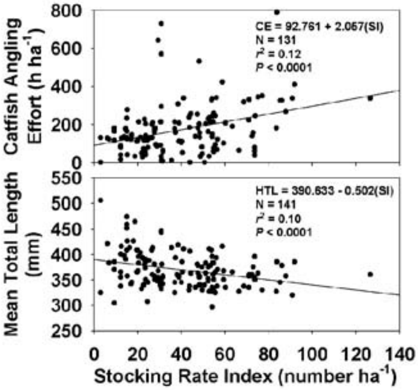

Figure 4. Scatter plots showing the relationships between catfish angling effort (CE, h ha^{-1}) and the stocking rate index (SI, top panel) and mean total length (mm) of harvested channel catfish (HTL) and SI (bottom panel).

rate index after the $\log_e$-transformed catfish angling effort (LCE) was included in the stepwise regression model ($r^2 = 0.44$, $P < 0.0001$, $N = 131$):

$$HR = 0.611 - 0.92(LCE) + 0.004(SI).$$

Stocking rate may influence catfish angling effort and mean TL of harvested channel catfish. Catfish angling effort weakly increased with increases in the stocking rate index (Fig. 4). However, this relationship is probably significant because heavily-fished urban lakes usually received larger stockings of channel catfish. Mean TL of harvested channel catfish declined with increases in the stocking rate index (Figure 4). Mean TL of harvested channel catfish was unrelated to catfish angling effort ($P = 0.53$).

Discussion

Channel catfish was the most important sport fish species in some lakes, whereas in others they were relatively unimportant. Because stocking channel catfish is expensive, channel catfish management efforts should focus on those lakes where this species is important to anglers. Differences in the importance of channel catfish are probably due to regional differences in sport fish species preferences, water quality, human population density, and channel catfish stocking rates. In Missouri, channel catfish tend to be more popular in the northern half of the state, where the landscape is dominated by agriculture, compared to the southern half, where forest and pasture are more common. Lakes in northern Missouri are usually more productive than those in the southern portion which provides more favorable conditions for channel catfish. Channel catfish also tend to be popular in urban areas where some lakes are more intensively managed for channel catfish.

Channel catfish anglers harvested most of the fish they caught and kept relatively small (< 300 mm mean TL) channel catfish in several lakes. Schramm et al. (1999) and Wilde and Ditton (1999) found that harvest was more important to catfish anglers than for anglers that fished for other species. The probability that a channel catfish will be released by an angler decreases with fish size (Santucci et al. 1994) but can be very low even for small fish (Eder and McDannold 1987) as found in this study. For some lakes, a minimum size limit may be useful in deferring harvest if growth rates of channel catfish are satisfactory, hooking mortality is low, and exploitation is high (Santucci et al. 1994). However, angler desires should be considered before imposing a minimum length limit. In the one study lake with a minimum size limit, anglers harvested only a third of the fish they caught due to the size restriction, and the average size they harvested was 472 mm and 448 mm TL for the two years, respectively, which was much higher than the average TL of fish harvested in most lakes.

Channel catfish harvest was more strongly associated with catfish angling effort than stocking rate. In contrast, Shaner et al. (1996) found that the biomass and number of catfish stocked were stronger predictors of harvest than angling effort. However, angling effort was not partitioned by sport fish species in the study by Shaner et al. (1996), thus actual angling effort directed toward catfish may have been a stronger predictor of catfish harvest than the total angling effort, as it was in this study. The broader range in stocking rates reported by Shaner et al. (1996), relative to this study, increased the likelihood of finding a strong relationship between stocking rate and harvest.

In our study, the reduction of typical stocking rates over the study period (Eder et al. 1997) was probably unnoticed by most anglers because harvest was not closely linked to stocking rates. Reductions in stocking rates were prompted by evidence that channel catfish in many small lakes were slow growing and their size structure was poor, which are indications of overstocking (Eder et al. 1997, Mitzner 1999). The observed decrease in mean TL of harvested channel catfish with increases in the stocking rate index support this conclusion. There was likely a surplus of channel catfish in most lakes and harvest was regulated by factors other than channel catfish abundance.

Heavily–fished urban lakes are likely an exception to the above scenario. Exploitation of channel catfish in small lakes can be high (Eder and McDannold 1987, Santucci et al. 1994, Parrett et al. 1999), especially in urban lakes that receive high fishing pressure. The consistently low harvest rates for heavily-fished lakes suggest that depletion of channel catfish stocks may have occurred.

In conclusion, our analysis revealed that channel catfish harvest was highly variable among lakes and was strongly associated with the amount of angling effort. We suggest that criteria be developed for stocking rates that account for differences in both angling effort and channel catfish population characteristics among lakes. Lakes that receive heavy fishing pressure will need to receive larger stockings than lakes with low fishing pressure provided growth rates of channel catfish in these lakes are satisfactory. For lightly-fished lakes, stocking rates even lower than the typical rates used in the 1990s (25–49 fingerlings ha^{-1}) may provide adequate harvest while allowing for good growth rates of channel catfish.

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