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EFFECTS OF POPULATION DENSITY AND FISHING PRESSURE ON HOOK-AND-LINE VULNERABILITY OF LARGEMOUTH BASS

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ABSTRACT

A two-part investigation was conducted on the angling vulnerability of northern largemouth bass, *Micropterus salmoides salmoides*, by manipulating population density in experimental ponds and fishing pressure applied to these populations. In the first experiment, three 0.08-hectare ponds were stocked with different densities of largemouth bass (50, 150, and 300 per hectare), and each pond was fished an equal number of hours. Catch per hour values for the low, medium, and high density ponds were 0.11, 0.72, and 1.61, respectively. The data indicated that a direct relationship exists between population density and the catch rate of largemouth bass. In the second experiment, three 0.08-hectare ponds were stocked with equal densities of largemouth bass (175 per hectare) and each pond was subjected to a different level of fishing pressure. The low pressure pond received 70.83 hours per hectare and yielded 2.99 bass per hour. The moderate pressure pond received 141.67 hours per hectare and yielded 1.15 bass per hour. The high pressure pond received 283.33 hours per hectare and yielded 0.35 bass per hour. The data indicated that an inverse relationship exists between fishing pressure and the catch rate of largemouth bass.

INTRODUCTION

Previous studies have demonstrated the effects of population density on growth, production, and catch rate of sport fish (Backiel and Le Cren 1967; Bennett 1954, 1971; Bennett et al. 1969). Bennett et al. (1969) reported that population densities and weights of bluegill, *Lepomis macrochirus*, and largemouth bass, *Micropterus salmoides*, were the most important differences between "good and poor" fishing years in a 7.28 hectare Illinois lake. They observed that for years in which the fish populations were dense, competition for available food resulted in higher catch rates. According to Beukema (1969) initial angling success for carp, *Cyprinus carpio*, increased rapidly with increased stocking densities. Data documented by Beaty and Childers (1980) indicated high correlation (r = 0.80) between population density and catch rate in four 0.1-hectare ponds, each containing largemouth bass, smallmouth bass (*Micropterus dolomieui*), and F_1 hybrids (female largemouth bass × male smallmouth bass). Aldrich (1939) noted, however, that in Spavinaw Lake, Oklahoma, increasing the density of the largemouth bass population did not result in a proportionate increase in catch rate. A study of several Illinois ponds (Hansen et al. 1960) also found little correlation between numbers of bass and bluegills and the catch rate.

The relationship between population density and catch rate is subject to numerous variables (e.g., food availability, social behavior, and hook-avoidance learning). Lagler and De Roth (1953) reported that population density of largemouth bass (TL 254 mm) influenced angling success in the Upper and Lower Loch Alpine ponds in Michigan. Lower Loch Alpine, containing 42 bass per hectare, yielded 0.25 bass per man-hour, whereas Upper Loch Alpine, containing 15 bass per hectare, yielded 0.04 bass per man-hour. However, total hours of fishing pressure placed upon the two ponds were not equal (232 man hours in Lower L.A. and 79 man hours in Upper L.A.). The differential fishing pressure may have greatly affected catch rate. The effect of fishing pressure needs to be assessed independently (Bennett and Weiss 1959; Anderson and Heman 1969). The objectives of this study were to reexamine for populations of largemouth bass under controlled experimental conditions: (1) the relationship between population density and catch rate and (2) the relationship between fishing pressure and catch rate.

METHODS

The study was conducted at the Aquatic Research Field Laboratory of the Illinois Natural History Survey, located on the Urbana-Champaign campus of the University of Illinois. Northern largemouth bass, *Micropterus salmoides salmoides*, collected from a 5.7-hectare lake which had received minimal fishing pressure, were stocked into three 0.08-hectare ponds. Spaghetti-type tags (Floy FD-68B) were attached to each fish below the dorsal fin. Those fish which lost either the numbered sleeve or the entire tag were retagged when caught by fishermen.

POPULATION DENSITY EXPERIMENT

In October 1978, Pond A (low density) was stocked with four largemouth bass (50 bass per hectare); Pond B (medium density) with 12 largemouth bass (150 bass per hectare); and Pond C (high density) with 24 largemouth bass (300 per hectare). All bass were weighed, measured, and tagged prior to stocking; mean total lengths and weights were similar (Table 1). Each of the three ponds was stocked with approximately 0.8 kg of fathead minnows, *Pimephales promelas*, as forage in fall 1978 and in spring 1979.

To allow for acclimation of the fish and to determine handling mortality, the ponds were not fished for 2 weeks after stocking. Thereafter, fishing was conducted in discrete 45 minute test periods. During a 45 minute test period, each of the three ponds was fished for 15 minutes. As a result, each population received the same fishing pressure at approximately the same time. To minimize hook-and-line mortality, fishermen were restricted to artificial lures. During a test period, a given lure was used equivalently in each of the three ponds. All largemouth bass caught were weighed, measured, fin clipped, and returned to their respective ponds. Fishing was conducted for 1 week in fall 1978 (16-20 October) and 7 weeks in 1979 (11 May - 9 July). Each pond was fished 4.5 hours (56 hours per hectare) in fall and 13.5 hours (169 hours per hectare) in spring, totaling 18 hours (225 hours per hectare) for the experiment. Upon termination of the experiment, the ponds were drained and largemouth bass were weighed and measured. All largemouth bass originally stocked were recovered.

FISHING PRESSURE EXPERIMENT

In September 1979, three 0.08-hectare ponds were stocked with 14 largemouth bass; mean total lengths and weights were similar (Table 2). To provide forage each pond was stocked in fall 1979, with 1.36 kg of sticklebacks, *Eucalia inconstans*.

Ponds were not fished for 2 weeks after stocking to allow for acclimation and determination of handling mortality. Thereafter, fishing was conducted in discrete 70 minute test periods. During a given 70 minute fishing period Pond A was fished for 10 minutes, Pond B for 20 minutes, and Pond C for 40 minutes. Each 70 minute test period was considered one trial by one fisherman. Fishing was conducted 22 April - 20 June 1980 providing 34 fishing trials. The fishing experiment was divided into two sessions. Session I included the first 4 days of the fishing experiment, when 11 trials were conducted to determine the effect of intense fishing pressure over a short time period. Fishing throughout Session II, the remainder of the experiment, averaged one fishing trial every 2 days, totalling 23 trials over a 7 week period. At the end of the experiment, all ponds were drained and largemouth bass were measured and weighed. All 14 largemouth bass were recovered from Pond B; Ponds A and C each had 13 bass at the time of draining.

RESULTS

Population Density Experiment

Catch rates for the combined fall and spring fishing sessions in the low, medium, and high density ponds were 0.11, 0.72, and 1.61 bass per hour, respectively (Table 3). Two of four (50%) bass were caught in the low density pond; nine of 12 (75%) in the medium, and 20 of 24 (83.3%) in the high density pond. The low density pond was the only one in which no recaptures occurred (Fig. 1). Of the nine individual largemouth bass caught in the medium density pond, seven were caught once each, and three twice each, yielding 13 captures. In the high density pond, of 20 individuals caught, 12 were caught once each, seven twice each, and one three times, a total of 29 captures. A positive correlation ($r = 0.99$) existed between the catch rate of largemouth bass and population density in the experimental ponds (Fig. 2). Theoretically, one might expect that as population density increased there would be an accompanying proportional increase in rate of catch. However, comparing low and medium density ponds, as density increased by a factor of three, catch rate increased by a factor of 6.6. Comparison of low and high density ponds revealed a similar effect; as density increased by a factor of six, catch rate increased by a factor of 14.6. This descrepancy was not as pronounced when comparing medium and high density ponds: as density increased by a factor of two, catch rate increased by a factor of 2.2.

Fishing Pressure Experiment

During spring Session I, ponds A and B yielded two largemouth bass, while in Pond C no bass were captured despite high fishing pressure. In Session II, anglers captured 15 largemouth bass in Pond A, 11 in Pond B, and 8 in Pond C. During the same period, catch rates per hour were 3.92, 1.43, and 0.52, respectively (Table 4). Catch rates of the combined two spring fishing sessions (34 trials) also decreased as pressure increased (Table 4). Numbers of largemouth bass caught per hour in ponds A, B, and C were 2.99, 1.15, and 0.35, respectively. There was a significant negative correlation (−0.913) between catch rate and fishing pressure over the entire spring period.

To determine possible effects of fishing pressure on catch rate within trial periods, numbers of bass caught during 10 minute segments of the trial periods were calculated (Table 5). Low pressure Pond A, which received only 10 minute fishing trials, was compared to the first 10 minutes of fishing in moderate pressure (20 minute trial) Pond B and high pressure (40 minute trial) Pond C. Eighty-five percent of the bass captured in Pond B were captured during the first 10 minutes of each fishing trial. The first 10 minutes of angling in Pond C, however, yielded only 37.5% of the total catch. By the time 200 hours per hectare (24 trials) had accumulated in Pond C, the catch rate dropped to zero, while in Pond B zero catch rate occurred after 121 hours per hectare (29 trials). Pond A continued to yield largemouth bass throughout the experiment (70.83 hours per hectare for 34 trials).

In Pond A, of 11 individual bass captured, five (45.5%) were captured only once, whereas six (54.5%) were captured twice each, totaling 17 captures (Fig. 3). In Pond B, of 11 individual bass captured, nine (82%) were each caught once, whereas two (18%) were caught twice each, totaling 13 captures. In Pond C, of six individual bass captured, four (67%) were each caught only one time and two (33%) were caught twice each, totaling eight captures.

As mentioned, the fish were fin clipped each time they were caught to insure detection of multiple captures when a tag was lost. This was indeed fortuitous, for of the 45 tags (including retagging) used during the population density experiment, 38% lost the numbered identification sleeve. In the fishing pressure experiment, 31% of 58 tags were lost. Fish were often observed striking at tags carried by neighboring individuals.

DISCUSSION

Assuming that higher density populations of largemouth bass have a greater number of actively feeding individuals at a given time, catch rates for dense populations might be expected to be higher than those for sparse populations. Numerical values for "angling efficiency" (number caught per hour per density) of the three ponds were calculated (Table 3). These values indicate success rates on a per fish basis for each catch in a pond with a particular population density. In the low density pond, angling efficiency for catching one largemouth bass during 1 hour of fishing was 0.028; in contrast, medium and high density pond angling efficiencies were 0.060 and 0.067, respectively. Therefore, as the density increased, so did the angling efficiency for capturing any given fish. These results indicate that fewer bodies of water holding more fish at higher density would provide better harvest values than if the same fish were spread over more bodies of water at lower density. These increased efficiencies are presumably due to increased aggressiveness among the largemouth bass as a result of increased competition for food resources. Bennett et al (1969) concluded that as fish populations became more dense, competition for available food resulted in higher catch rates. Similar results have been reported by some researchers (Lagler and De Roth 1953; Beukema 1969; Beaty and Childers 1980), while conflicting results are suggested by others (Aldrich 1939; Hansen et al. 1960). Our results agree with those studies showing a positive relationship between increased population density and "high" catch rate.

All three ponds were stocked with equal amounts of forage; however, only the low density pond contained minnows (3.75 kg) at the end of the experiment. The largemouth bass in all ponds spawned during the study, and at the time of draining the number of surviving offspring recovered from the low, medium, and high density ponds were 6,263, 4,549, and 1,393, respectively. Mean lengths of juvenile largemouth bass in the three ponds were 34, 47, and 51 mm, respectively. The negative relationship between number of spawners and resulting year class indicated severe cropping of juveniles by adults in both medium and high density ponds. Adult largemouth bass in the low density pond gained weight, while adults in the other two ponds lost weight. These results indicate that food resources were indeed limiting in the medium and high density ponds (Table 1).

Our data indicate that vulnerability to angling decreased as fishing pressure accumulated (Fig. 3). Data from Anderson and Heman (1969) suggested that largemouth bass vulnerability may have been inversely related to previous fishing pressure. Analyzing lakes and ponds from both Illinois and Missouri, Bennett and Weiss (1959) found at fishing pressures below 325 hours per hectare, catch rate increased rapidly and was greatest when pressures were between 100 and 150 hours per hectare. In our experiment, the highest rate of catch was in Pond A, which received 70.83 hours per hectare, the lowest fishing pressure studied. Furthermore, in moderate and high pressure ponds (B and C), the rate of decline in catch per hour within ponds showed a temporal trend of decreasing vulnerability as fishing pressure accumulated. There was no progressive decline in catch rate in low pressure Pond A.

Both experiments presented were conducted in small inpoundments (0.08-hectare); with only one size class of largemouth bass (230 to 310 mm). Effects of limited food resources in a lake or pond are likely to be compounded by the presence of other size classes of bass and other species of fish. As a result of these limitations, we suggest that further studies be conducted and analyzed carefully before relating results to larger bodies of water. However, based on our data, an individual body of water can be managed for maximum catch rate and efficiency by controlling population density of largemouth bass and fishing pressure. Clearly, density of largemouth bass in a pond can be increased to a point at which food resources become insufficient to support growth. Even with increases in catch rate due to increased population densities, stunted largemouth bass caught from an overpopulated pond might lower the quality of fishing. In any case, a management program for a given largemouth bass population must be designed so that both growth potential and angling are considered.

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Table 1. Length and weight of largemouth bass at time of stocking and draining of three ponds for the population density experiment.

	POND A low density[a]	POND B medium density[b]	POND C high density[c]
Stocking			
Number	4	12	24
Mean Total Length (mm)	272 ± 9	271 ± 24	271 ± 14
Mean Total Weight (g)	329 ± 57	316 ± 88	314 ± 55
Draining			
Number	4	12	24
Mean Total Length (mm)	307 ± 13	285 ± 15	278 ± 12
Mean Total Weight (g)	413 ± 41	301 ± 41	275 ± 37
Percent of Change			
Mean Total Length (mm)	+ 12.9	+ 5.2	+ 2.6
Mean Total Weight (g)	+ 25.5	− 4.8	− 12.4

Standard deviations are indicated to the right of each value.
[a]Low density: 4 individuals (50 per hectare).
[b]Medium density: 12 individuals (150 per hectare).
[c]High density; 24 individuals (300 per hectare).

Table 2. Length and weight of largemouth bass at time of stocking and draining for the fishing pressure experiment.

	POND A low pressure[a]	POND B moderate pressure[b]	POND C high pressure[c]
Stocking			
Number	14	14	14
Mean Total Length (mm)	266 ± 29	268 ± 29	263 ± 30
Mean Total Weight (g)	283 ± 75	290 ± 89	278 ± 83
Draining			
Number	13	14	13
Mean Total Length (mm)	290 ± 22	278 ± 24	292 ± 32
Mean Total Weight (g)	330 ± 59	272 ± 80	336 ± 103
Percent of Change			
Mean Total Length (mm)	+ 9.0	+ 3.7	+ 11.0
Mean Total Weight (g)	+ 16.6	− 6.2	+ 20.9

Standard deviations are indicated to the right of each value.
[a]Low pressure: 10 minutes per trial.
[b]Moderate pressure: 20 minutes per trial.
[c]High pressure: 40 minutes per trial.

Table 3. Combined rates of the fall and spring sessions for three ponds stocked with different densities of adult largemouth bass. Angling efficiencies are shown as catch rate divided by density.

	POND A low density[a]	POND B medium density[b]	POND C high density[c]
Catch per hour	0.11	0.72	1.61
Catch rate per density	0.028	0.060	0.067
Kilograms per hour	0.03	0.20	0.42

[a]Low density: 4 individuals (50 per hectare).
[b]Medium density: 12 individuals (150 per hectare).
[c]High density: 24 individuals (300 per hectare).

Table 4. Fishing pressure and catch rates for largemouth bass fishing pressure experiment.

	POND A low pressure[a]	POND B moderate pressure[b]	POND C high pressure[c]
Spring 1980 - Session I			
April 22-25 (11 trials)			
Hours fished	1.83 (22.92 per ha)	3.67 (45.83 per ha)	7.33 (91.63 per ha)
Catch per hour	1.09	0.55	0.00
Catch per hectare	25.0	25.2	0.0
Spring 1980 - Session II			
May 1-June 20 (23 trials)			
Hours fished	3.83 (47.88 per ha)	7.67 (95.88 per ha)	15.33 (191.63 per ha)
Catch per hour	3.92	1.43	0.52
Catch per hectare	187.5	137.5	100.0
Total of Sessions I and II			
April 22-June 20 (34 trials)			
Hours fished	5.67 (70.83 per ha)	11.33 (141.67 per ha)	22.67 (283.33 per ha)
Catch per hour	2.99	1.15	0.35
Catch per hectare	211.5	162.5	99.2

[a]Low pressure: 10 minutes per trial.
[b]Moderate pressure: 20 minutes per trial.
[c]High pressure: 40 minutes per trial.

Table 5. Number of largemouth bass caught in three fishing ponds (A, B, and C) during the first, second, third, and fourth 10 minutes across 34 fishing trials for the combined two spring fishing sessions.

Spring 1980	POND A low pressure[a]	POND B moderate pressure[b]	POND C high pressure[c]
1st 10 minutes	17 (100%)	11 (85%)	3 (37.5%)
2nd 10 minutes	--	2 (15%)	2 (25%)
3rd 10 minutes	--	--	0
4th 10 minutes	--	--	3 (37.5%)
TOTAL	17	13	8

[a]Low pressure: 10 minutes per trial.
[b]Moderate Pressure: 20 minutes per trial.
[c]High pressure: 40 minutes per trial.

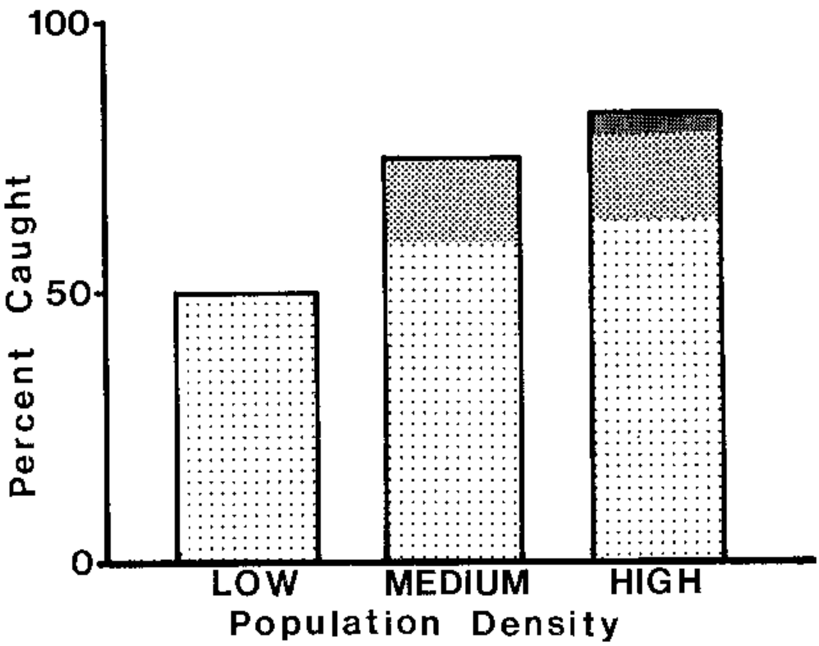

Figure 1. Precentage of largemouth bass population caught in Pond A (low density), Pond B (medium density), and Pond C (high density). Lightly shaded areas indicate percentage of captured bass caught one time; darker shaded, two times; and heavily shaded, three times.

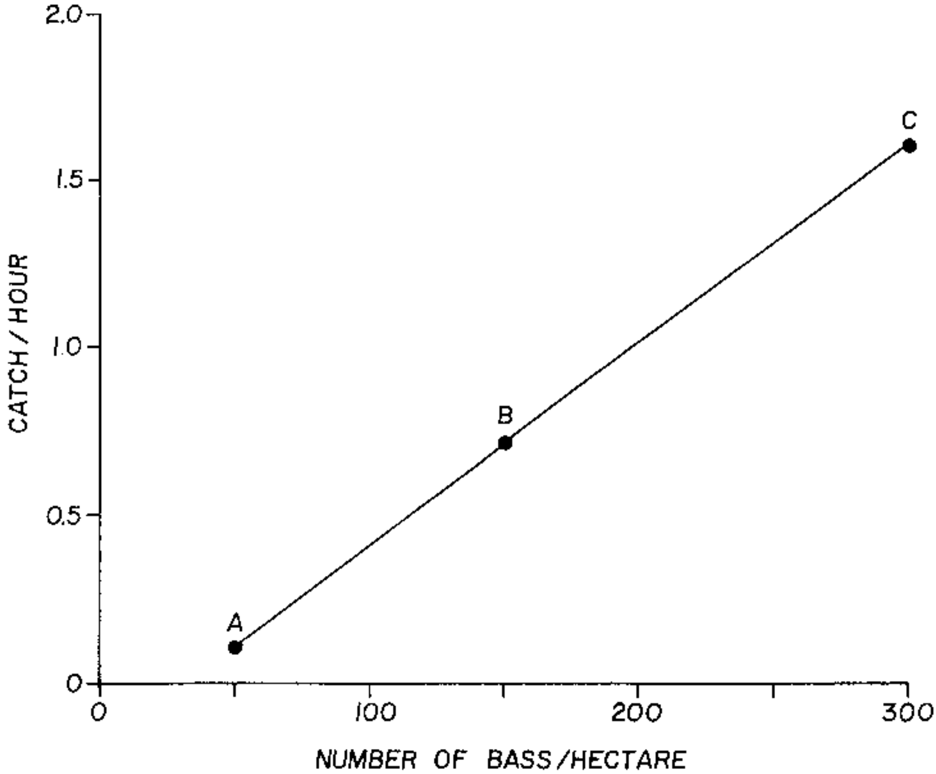

Figure 2. Relationship between catch rate and population density of largemouth bass in Pond A (low density), Pond B (medium density), and Pond C (high density).

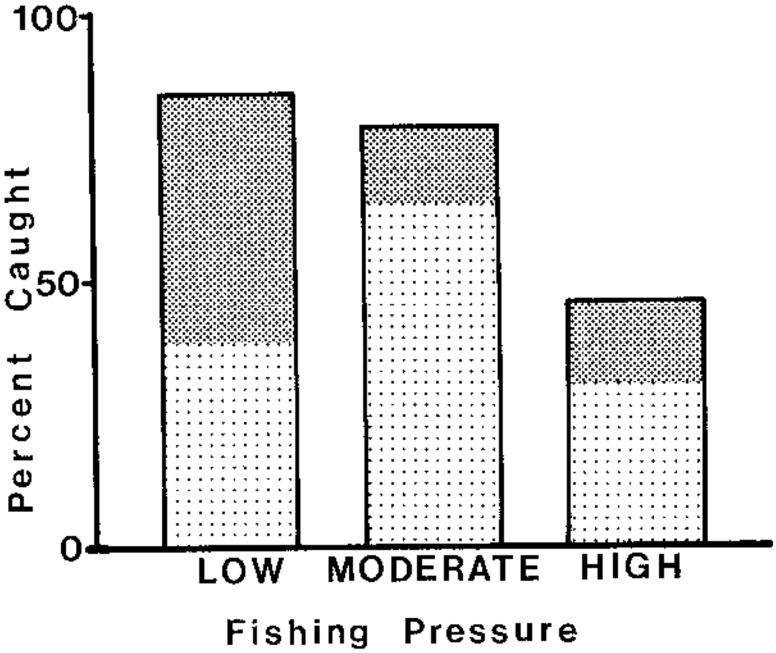

Figure 3. Percentage of largemouth bass population caught in Pond A (low pressure), Pond B (moderate pressure), and Pond C (high pressure). Lightly shaded areas indicate percentage of captured bass caught one time, and darker shaded areas indicate two times.

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