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Hook-and-Line Vulnerability and Multiple Recapture of Largemouth Bass under a Minimum Total-Length Limit of 457 mm[1]

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Abstract.—Data from a catch-and-release largemouth bass (*Micropterus salmoides*) fishery at Ridge Lake, Illinois, in which the minimum size limit was 457 mm total length, were used to test the null hypothesis that the recapture of largemouth bass is a normally distributed random event. Comparison of recapture data with a Poisson distribution for randomly selected fish from the 1976 year class demonstrated that recapture was not a random phenomenon and implied that individual fish varied in their vulnerabilities. "Low" and "high" vulnerabilities to capture existed among individuals in the largemouth bass population in Ridge Lake. Hook-and-line vulnerability of individuals varied among fishing seasons. Approximately 15% of the largemouth bass longer than 200 mm that were recovered when the lake was drained had never been caught during the four seasons of catch-and-release fishing. However, tagged largemouth bass were caught, on the average, approximately twice in any catch-and-release season.

The overharvest of largemouth bass (*Micropterus salmoides*) has long been a major concern of fisheries biologists (Turner 1963; Anderson 1974; Graham 1974; Redmond 1974). Catch-and-release programs in conjunction with minimum-length limits have been proposed as possible solutions to overharvesting. The catch-and-release management technique is designed to increase the sportfishing pleasure for a large number of fishermen while retaining adequate numbers of largemouth bass and forage fish.

The success of catch-and-release fishing as a management practice is based upon the survival, growth, and recapture of released fish. However, it has been proposed that previously caught largemouth bass may learn to avoid subsequent hooking events, thereby limiting the chances of recapture of released fish (Aldrich 1939; Anderson and Heman 1969; Bennett 1974).

This study was designed to determine if individual differences in hook-and-line vulnerability existed in a population of largemouth bass in a fishery with a minimum size limit of 457 mm total length (TL), and to quantify the magnitude of such differences.

Methods

Ridge Lake, a 6.3-hectare lake located in Fox Ridge State Park, Coles County, Illinois, was drained in March 1976. Rotenone was applied to all water left in the basin to eliminate the remaining live fish. After the lake refilled, adult largemouth bass, channel catfish (*Ictalurus punctatus*), and F_1 hybrid sunfish (female bluegill [*Lepomis macrochirus*] × male green sunfish [*Lepomis cyanellus*]) were stocked into the lake in 1976 at these quantities (number and total weight): 410 largemouth bass (125.2 kg); 800 channel catfish (363.6 kg); and 2,413 hybrid sunfish (37.2 kg). Largemouth bass were stocked on 10 and 11 May, channel catfish on 15 and 16 May, and hybrid sunfish on 20 and 27 July. Additional channel catfish were stocked each year from 1977 to 1980 to replace those removed by anglers and to main-

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TABLE 1.—Fishing seasons in Ridge Lake, Illinois, 1976–1980.

Year	Opening	Closing
1976	5 June	29 August
1977	17 May	15 October
1978	20 May	15 October
1979	20 April	14 October
1980	19 April	21 September

tain the fishery in the presence of an established largemouth bass population.

A complete creel census of Ridge Lake was conducted throughout each fishing season, 1976 through 1980, according to methods described in detail in Burkett et al. (1981a). The duration of each fishing season is shown in Table 1. During 1976, all largemouth bass caught by fishermen, regardless of size, were harvested. Beginning in 1977 and extending throughout the remainder of the experiment, catch-and-release largemouth bass fishing was imposed through the use of a 457-mm minimum-length limit. In addition to the total length and weight measurements recorded for each largemouth bass caught, all individuals shorter than 201 mm were fin-clipped to identify the year of capture; those longer than 200 mm were given a different year-specific fin clip and were tagged with an individually numbered Floy anchor tag (FD-68B).

A population subsample of 200 largemouth bass was collected by electrofishing during a 4-week period in April–May 1980. A total of 78 individuals belonging to the 1976 year class (identified by scale analyses) were collected, and these 78 individuals were included in a Poisson distribution to determine if differences in hook-and-line vulnerability existed among individuals within the largemouth bass population. Only individuals belonging to the 1976 year class were analyzed in order to avoid the effects of differing cumulative fishing pressure and other temporal variables associated with fish of differing year classes. Through examination of creel records, the 78 largemouth bass were assigned to one of nine capture-frequency categories. Those in the 0 category were never captured during 1977, 1978, or 1979. Those in the 1 category had been captured once during the three seasons, those in the 2 category had been captured twice, and so on.

Following the draining of the lake, total hook-and-line capture frequencies were tabulated for

TABLE 2.—Contribution of capture-frequency deviations from expected Poisson distribution frequencies to the chi-square statistic. (Values have been rounded to two decimal points for display.)

Capture frequency	Observed	Expected (E)	Deviation (D)	Contribution to chi-square (D^2/E)	Percent contribution to chi-square
0	10	5.35	4.65	4.04	26.38
1	15	14.34	0.66	0.03	0.20
2	16	19.21	3.21	0.54	3.50
3	13	17.16	4.16	1.01	6.57
4	11	11.49	0.49	0.02	0.14
5	5	6.16	1.16	0.22	1.42
6	3	2.75	0.25	0.02	0.15
7	4	1.05	2.95	8.25	53.88
8	1	0.35	0.65	1.19	7.76
Sum				15.31	

TABLE 3.—Recoveries, by size class, of largemouth bass from Ridge Lake, Illinois, in 1980, and the proportions of these that had been caught at least once during the catch-and-release seasons of 1977–1980.

Size class (total length, mm)	Number recovered at draining	Number previously caught	Percent previously caught
201–254	304	178	58.6
255–356	1,451	1,322	91.1
357–457	18	18	100
>457	14	14	100
Totals	1,787	1,532	85.7

TABLE 4.—Hook-and-line capture frequencies for largemouth bass caught at Ridge Lake, Illinois, during the 1977–1980 fishing seasons. Data are numbers of fish.

Capture frequency	Fishing season				Overall (1977–1980)
	1977	1978	1979	1980	
1	62	940	1,360	789	188
2	71	886	727	511	330
3	52	390	390	252	378
4	19	169	164	121	327
5	12	71	78	62	205
6	8	35	43	24	134
7	1	11	10	7	84
8	0	2	3	2	42
9	1	3	9	2	40
10	0	1	7	1	11
11	0	0	5	0	11
12	0	0	1	1	10
13	0	0	0	0	5
14	0	0	2	0	2
15	0	0	1	1	3
16	0	0	1	1	0
17	0	0	0	0	2
18	0	0	0	0	0
19	0	0	0	0	1
20	0	0	0	0	1
21	0	0	0	0	0

TABLE 5.—Capture summary for largemouth bass longer than 200 mm total length in Ridge Lake, Illinois, during the 1977–1980 fishing seasons.

Season	Number of individuals caught	Total number of captures	Average number of captures per individual
1977	226	560	2.5
1978	2,508	5,253	2.1
1979	2,801	5,695	2.0
1980	1,774	3,641	2.1
Cumulative[a]	1,774	6,969	3.9

[a] Four-year cumulative captures for fish caught in 1980. The other, annual, values are mutually independent.

each fishing season, for each size class, and for individual capture-frequency classes. Capture profiles for several fish also were prepared to illustrate vulnerability patterns typical of these recaptured largemouth bass.

Results and Discussion

Poisson distribution probabilities were calculated based upon 78 individual largemouth bass that were caught a total of 209 times. A chi-square value of 15.31 was calculated to determine the probability of randomly observing a larger chi-square value. The chi-square value for the Poisson distribution was between 0.01 and 0.005, allowing rejection of the null hypothesis. We concluded that the recapture of individual largemouth bass was not random and that individual variability was associated with hook-and-line capture.

A bimodal distribution of the percentage of contribution by the various capture-frequency categories to the chi-square statistic was evident also (Table 2). The 0 category contributed 26.38% to the chi-square statistic and the 6 and higher categories contributed 61.79%. This distribution supports the theory of the existence of largemouth bass stocks of "low" and "high" vulnerability.

When Ridge Lake was drained in October 1980, 14.3% of the largemouth bass longer than 200 mm had not been caught during the four seasons of catch-and-release fishing (Table 3). These 255 individuals were mostly in the 201–254-mm size range. There was a general trend toward fewer uncaught individuals in the larger size classes, and all fish longer than 357 mm were caught at least once.

Numbers of largemouth bass caught in each capture-frequency class during each fishing season and cumulatively for all seasons are given in Table 4. Some fish were caught as many as 16 times in a single season and one individual was caught 20 times during the 4-year experimental period. On the average, largemouth bass were caught approximately twice during any given fishing season (Table 5). Between 1977 and 1980, the 1,774 fish that were caught in 1980 had been captured a total of 6,969 times or approximately four times each.

TABLE 6.—Hook-and-line capture frequencies for randomly selected largemouth bass of the 1976 year class that survived the fishing seasons of 1977–1980 in Ridge Lake, Illinois. Data are numbers of times each fish was caught.

Floy tag number	Fishing season				Totals
	1977	1978	1979	1980	
579	1	4	3	1	9
603	0	5	4	0	9
639	2	2	9	0	13
718	1	8	4	1	14
785	1	6	4	1	12
977	1	5	2	5	13
1024	0	9	0	0	9
1293	1	1	1	1	4
2773	1	2	5	5	13
2837	0	1	15	0	16
2986	2	2	9	0	13
3657	1	0	1	2	4
3827	0	1	2	12	15

The annual distribution of hook-and-line captures of 13 randomly selected largemouth bass of the 1976 year class illustrates the variation in their vulnerability (Table 6). For example, one largemouth bass (tag 1293) was caught once during each catch-and-release season; another fish (tag 3827) was not caught in 1977 but was caught once in 1978, twice in 1979, and 12 times in 1980.

Having established the individuality of hook-and-line vulnerability of largemouth bass subjected to catch-and-release fishing, we also have demonstrated that the vulnerability of an individual largemouth bass may vary from year to year, although not in a consistent manner. Burkett et al. (1981b) discussed the role of the physicochemical environment on vulnerability, and Mankin et al. (1984) suggested relationships between population density and fishing pressure to hook-and-line vulnerability.

Management Implications

The implications of these findings for largemouth bass management are certainly important. If, indeed, not all largemouth bass are equally vulnerable to the angler's lure, then the stocking densities of catchable-size fish should be re-evaluated.

In addition, the possibility that different genetic stocks of largemouth bass have quite different hook-and-line vulnerabilities suggests that selective breeding might yield stocks of differing vulnerabilities that can meet particular management needs. If successful, this technique would provide an entirely new dimension for sport-fisheries management. Preliminary results in our laboratory strongly support this hypothesis that hook-and-line vulnerability is heritable.

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