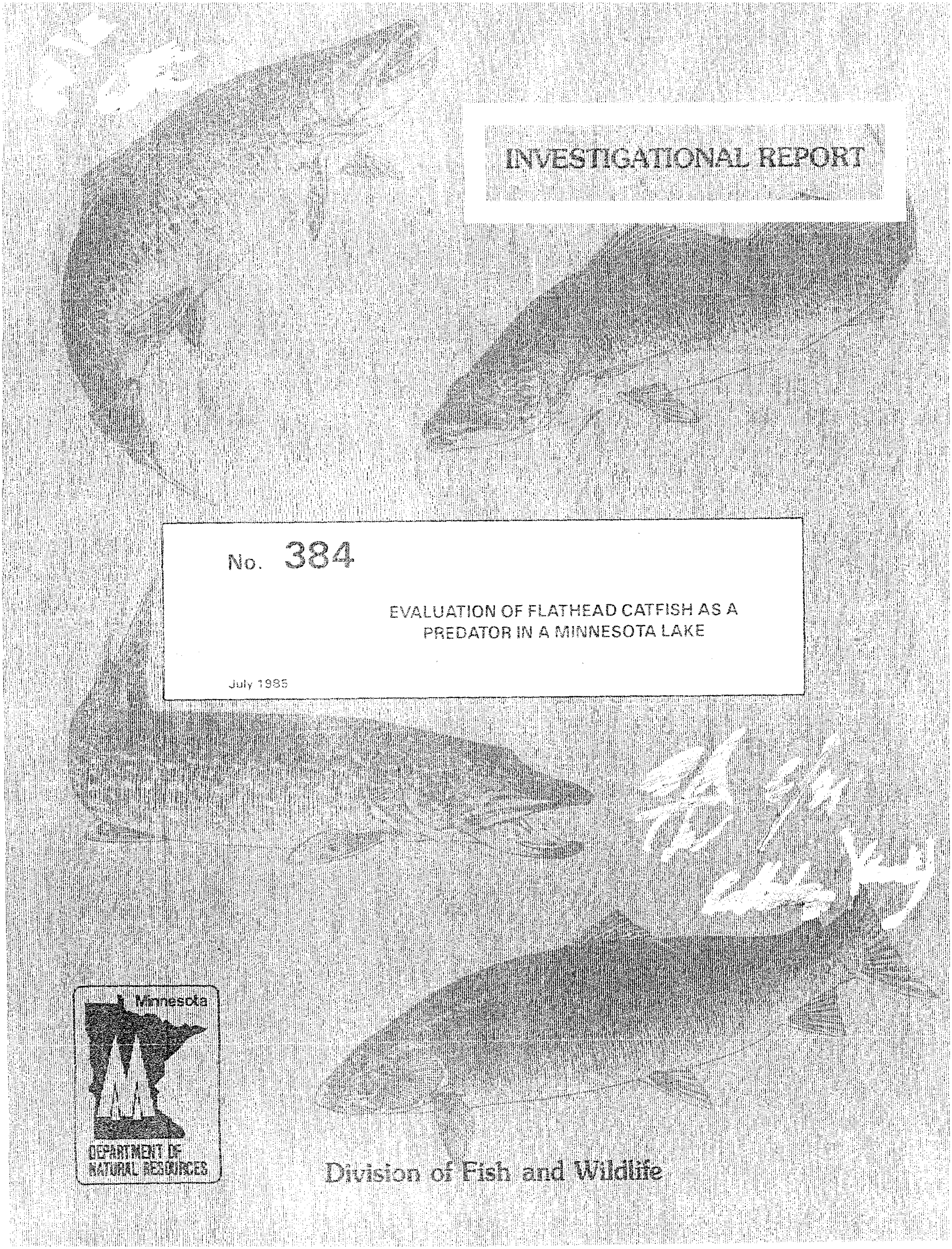

INVESTIGATIONAL REPORT

No. 384

EVALUATION OF FLATHEAD CATFISH AS A PREDATOR IN A MINNESOTA LAKE

July 1985

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Division of Fish and Wildlife

EVALUATION OF FLATHEAD CATFISH AS A PREDATOR IN A MINNESOTA LAKE[1]

by

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ABSTRACT

Introduced adult flathead catfish induced profound changes in fish population structure within one year in a small, fertile lake. Carp and bullhead numbers were reduced to less than 10% of their original levels and CPUE for most other species also declined. These changes in abundance were reflected in improved growth rate for carp only. Stocked flathead catfish were most effectively sampled with large-mesh gill nets and many were caught repeatedly. The primary food items found in flathead catfish stomachs were carp and black bullhead with other species present in low numbers. Prey size was not related to flathead catfish total length or weight, indicating that they were as much opportunistic as selective feeders. Growth and condition of flathead catfish were directly related to length of time in the lake and inversely related to size at stocking. Mean K factors were higher than those reported for any other locale. Age-length relationship was extremely variable which is typical for flathead catfish from most regions of the country. More study will be needed to determine optimum sizes and rates for stocking fingerling catfish as a biological control.

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[1] This project was funded in part by Federal Aid Fish Restoration (Dingell-Johnson) Program. Completion Report, Study 121, Project D-J F-26-R Minnesota.

INTRODUCTION

The reputation of the flathead catfish (Pylodictus olivaris) as a piscivore and its rapid growth to considerable size have prompted many attempts to use it to control unbalanced fish populations. Different stocking rates and sizes have been used in a variety of circumstances with varying results. An example of a highly successful stocking was its introduction into the Cape Fear River, N.C. Guier et al. (1980) found that a single stocking of 11 adults (170 kg total weight) populated a 201 km stretch of river within 15 years, eliminating brown bullheads (Ictalurus nebulosus) and reducing the abundance of other Ictalurids. Swingle et al. (1965) stocked flathead catfish fingerlings at 123/ha and found that they successfully reduced a population of intermediate-sized bluegills (Lepomis macrochirus) to the point where natural reproduction of bluegills resumed. However, Bamberg (1975) stocked small fingerlings (41 mm TL) at 27/ha into a 259 ha reservoir in Texas with no success and Hackney (1965) observed only a slight reduction in bluegill numbers one year after stocking fingerlings (305-407 mm TL) at 123/ha. Swingle (1964) stocked fingerlings as small as 38 mm TL to determine if they would survive and eventually prey on bluegills. He found no evidence of their survival and attributed this to predation by bluegills.

These experiments led to an investigation of the stocking of flathead catfish as predators in Minnesota lakes to reduce the abundance of certain undesirable fish populations. The objective of this study was to determine if over-abundance of bullhead (Ictalurus spp.), carp (Cyprinius carpio) and small centrarchids (Pomoxis and Lepomis spp.) could be controlled by introducing a large, exclusively piscivorous predator such as the flathead catfish.

DESCRIPTION OF STUDY LAKES

Two small lakes with different species compositions were selected for stocking with flathead catfish. Richardson Lake, located in Meeker County, and Dog Lake, in Wright County, are situated in agricultural areas and have mixtures of residential development, cropland and marshes along their shorelines. Richardson Lake has a maximum depth of 14.3 m and a shoreline length of 2.9 km with 42% of its 44.9 surface hectares in the littoral zone. Dog Lake has a maximum depth of 7.6 m, 2.6 km of shoreline and 78% of its 37.8 hectares are littoral. Both lakes develop persistent thermoclines during the summer at depths of 3.7-6.2 m. Ice-out occurs between the first and third weeks in April and freeze-up is in late November. They are both fertile hardwater lakes with mid-summer pH values near 8.0 and mean total alkalinities of approximately 150 mg/l $CaCO_3$. Adequate dissolved oxygen is present above the thermocline in summer and neither lake has a recent history of winterkill.

Both lakes have bluegill and black (*Pomoxis nigromaculatus*) and white (*P. annularis*) crappie as the most numerous game fish species. Richardson Lake has a small walleye (*Stizostedion vitreum vitreum*) population resulting from sporadic stocking, abundant largemouth bass (*Micropterus salmoides*) and large populations of carp and black bullhead (*Ictalurus melas*). Dog Lake has largemouth bass, all three species of bullhead, with the yellow bullhead (*Ictalurus natalis*) the most abundant, and carp are present but rare.

Largemouth bass and crappie are the principal species caught by anglers at Richardson Lake and occasional northern pike (*Esox lucius*) are speared through the ice. Dog Lake is popular with bluegill and crappie anglers with quality largemouth bass and northern pike occasionally taken.

METHODS

Evaluation of the effects of stocking flathead catfish was conducted in three phases: (1) pre-stocking assessment of the potential prey population; (2) the introduction of flathead catfish and evaluation of their diet, growth and survival; and (3) assessment of abundance and growth of the prey population after catfish introduction. Pre-stocking assessment occurred in 1978 and post-stocking assessment was conducted from 1979 through 1982.

Potential prey species were sampled by 24-hour trapnet sets bi-weekly from June through September each year. Three 6.4 mm mesh single-frame and three 19 mm mesh double-frame trapnets with 12.2 m leads were used. The same sampling stations and approximately the same amount of effort were used each year. For each netting period, total numbers caught and total length and weight of all species were recorded and scale samples were obtained. Catches per unit effort (CPUE) were calculated separately for the two trapnet mesh sizes used but the catches were combined for this report since equal numbers of each net were set each sampling period.

Shoreline seining was conducted from June through August each year with a 9.1 m x 1.5 m x 6 mm net to monitor species not commonly taken in the trap nets. Periodic hauls were made at designated sampling stations with each haul covering approximately 0.02 ha. All specimens were identified to species except for y-o-y sunfish and number/ha seined was calculated for all species.

Flathead catfish were stocked as they became available from commercial fishermen in Illinois beginning in the fall of 1978. Each fish was measured, weighed and injected with terramycin as a prophylactic. All were marked with numbered disc-dangler tags and each was given a salt dip before release. A total of 1,021 flathead catfish with a mean weight of 1.7 kg were stocked into Richardson Lake during the period from October 1978 to April 1982. They were also to be stocked into Dog Lake, but because sufficient numbers of them could not be supplied on a regular basis, it was decided to leave Dog Lake as a control.

Several sampling methods were tested to find the optimum sampling technique for flathead catfish. Trotlines baited with live fish, slat traps and electrofishing were tried extensively for one season. Hoop nets, lake survey trap nets, experimental gill nets and whitefish gill nets (30.5 m x 0.9 m x 38 mm) were also used. Large-mesh gill nets of various lengths and materials were used more than any other type of gear. They were constructed of both multifilament (102 mm mesh, #277 twine size) and monofilament (89 mm) material. Net lengths varied from 30.5 m, 61.0 m and 76.2 m long. The monofilament nets were 3.1 m and the multifilament nets were 2.4 m in depth.

Each flathead catfish sampled was measured, weighed and its stomach contents were removed with a stomach pump (Seaburg 1957). Organisms found in the collecting jar were preserved in formalin for laboratory examination. In the laboratory, all organisms were identified at least to family when possible and total lengths of all intact identifiable fish species were measured. Left pectoral or dorsal spines were removed from catfish with a small, fine-toothed hacksaw and were preserved for later sectioning and aging. Spines were sectioned with a variable-speed rotary tool equipped with a 22 mm dental separating disc as a cutter. One-millimeter sections were cut, polished with emery cloth and then attached to a piece of transparent acetate with a few drops of polyester casting resin.

Scale samples were aged and growth rates were back-calculated for all scaled species taken by trap net and shoreline seining. Condition factors (K) were calculated using the formula $K = W \times 10^5/L^3$, where W = the weight of the fish in g and L = total length in mm.

Survival of flathead catfish was estimated using Ricker's formula (1975) for small numbers of recaptures:

Si = (R12) (M2) /Mi(R22+1), where

Si = Survival rate over year 1

Mi = number of fish marked at the start of the first year

M2 = recaptures of first-year marks in the second year

R12 = recaptures of first-year marks in the second year

R22 = recaptures of second-year marks in the second year

To assess feeding selectivity for prey species in the diet of flathead catfish, the electivity index "E" (Ivlev 1961) was calculated from the formula $E = (r-p)/(r+p)$ where r equals the relative content of a species in the ration and p equals the relative content of the same species in the environment. Values for E range from -1 to +1 with a negative value indicating a species was eaten in smaller proportion than it was present in the environment and a positive value indicating proportionately greater representation in the diet than in the environment. Values used in the calculations were r = the percentage of the total number of identifiable fish in the diet comprised of one species and p = the percentage of the total trapnet catch comprised of that same species in the same year.

RESULTS

Catch Indices for Prey Species

The introduction of 394 flathead catfish into Richardson Lake was soon followed by substantial declines in the trapnet catch indices for carp and bullheads (Table 1). Catch indices for prey species declined the most in 1979, the first year after catfish introduction (Table 2). CPUE for carp dropped from 44.3/trapnet set in 1978 to 6.0/set in 1979 and continued to

Table 1. Flathead catfish stocked into Richardson Lake, 1978-1982.

Year	Number	Mean weight(kg)	Total weight(kg)	kg/ha
1978	394	1.29	507.1	11.3
1979	463	0.88	405.1	9.0
1980	39	4.72	183.4	4.1
1981	66	4.04	266.6	5.9
1982	59	7.00	413.0	9.2
Totals	1,021	1.74	1,775.2	39.5

Table 2. CPUE of potential prey species in trap nets, 1/4- and 3/4-inch mesh combined, Richardson Lake, 1978-1982. (Number of trapnet sets in parentheses.)

Species	1978	1979	1980	1981	1982
	(46)	(30)	(47)	(47)	(42)
Carp	44.3	6.0	2.1	1.9	1.7
Black bullhead	31.7	3.3	23.5	7.6	7.9
Yellow bullhead	18.0	1.3	2.9	3.4	1.7
Brown bullhead	3.7	0.4	0.5	0.1	<0.1
Green sunfish	1.0	0.3	0.5	0.3	0.1
Pumpkinseed	1.6	0.3	0.5	0.3	0.2
Bluegill	13.5	12.6	25.9	23.4	17.8
White crappie	-	-	-	-	0.9
Black crappie	25.6	6.6	5.9	10.5	24.3
Hybrid sunfish	1.9	0.7	0.6	0.6	0.8
Yellow perch	4.8	0.2	0.3	0.5	0.3

decline each year through 1982. Black bullhead catches decreased by almost 90% from 1978 to 1979 and brown and yellow bullhead numbers dropped to less than 10% of their previous abundance by 1982. Lesser but still significant (t-test, $p < 0.05$) declines in CPUE also occurred for most other potential prey species. Black crappie decreased by almost 75% in 1979, then increased each year until 1982 when their numbers returned to 1978 levels. Bluegill numbers doubled from 1979 to 1980, then dropped slightly in 1981 and 1982.

Trapnet catch indices for potential prey species in Dog Lake were more stable from 1978 to 1982 than those at Richardson Lake (Table 3). The only significant change (t-test, $p < 0.05$) was for bluegill, which declined to 26.8% of its 1978 abundance by 1982. CPUE's for other species were less variable and no trends were evident.

Table 3. CPUE of potential prey species in trap nets, 1/4-inch and 3/4-inch mesh combined, Dog Lake, 1978-1982. (Number of trapnet sets in parentheses.)

Species	1978	1979	1980	1981	1982
	(29)	(24)	(33)	(29)	(38)
Black bullhead	1.9	1.5	1.2	1.0	1.1
Yellow bullhead	15.1	9.5	14.5	15.7	19.5
Brown bullhead	2.6	6.5	2.4	4.7	3.9
Pumpkinseed	2.0	2.0	2.4	1.3	4.8
Bluegill	75.7	31.8	28.1	21.8	20.3
White crappie	4.0	2.2	6.2	5.2	8.9
Black crappie	8.7	8.8	7.5	15.1	15.2
Hybrid sunfish	1.2	1.2	0.8	1.2	2.5
Yellow perch	0.1	-	-	<0.1	<0.1

Shoreline seine catches were more variable than trapnet catches at both Richardson and Dog lakes (Tables 4 and 5). However, declines in several species occurred at Richardson Lake, especially carp and black bullhead. At Dog Lake, the only apparent trend was an increase in abundance of y-o-y sunfish.

Table 4. CPUE of potential prey species in shoreline seine hauls, Richardson Lake, 1978-1982.

Species	Number/hectare				
	1978	1979	1980	1981	1982
Northern pike	4.7	10.6	3.2	68.9	20.5
Carp	676.6	-	16.6	8.6	-
Black bullhead	203.9	7.2	16.6	4.2	-
Green sunfish	127.3	3.5	3.2	4.2	-
Pumpkinseed	131.9	32.1	16.6	4.2	10.1
Bluegill	105.5	118.1	49.4	99.1	41.0
LM bass (age I+)	26.4	10.6	-	77.6	15.3
LM bass (y-o-y)	14.3	186.3	65.7	47.4	396.2
Black crappie	4.7	10.6	-	8.6	-
Hybrid sunfish	76.8	25.0	-	4.2	10.1
YY sunfish	433.8	132.4	78.8	43.0	46.2
Yellow perch	247.1	110.9	85.5	142.1	92.2

Table 5. CPUE of potential prey species in shoreline seine hauls, Dog Lake, 1978-1982.

Species	Number/hectare				
	1978	1979	1980	1981	1982
Northern pike	34.6	39.5	22.5	21.5	56.6
Yellow bullhead	5.0	9.1	-	7.2	-
Brown bullhead	7.4	6.2	-	-	-
Green sunfish	104.0	21.3	120.8	150.7	79.3
Pumpkinseed	332.1	163.8	433.9	273.0	226.6
Bluegill	691.4	258.0	161.4	718.3	113.4
White crappie	7.4	6.2	-	-	-
Black crappie	-	27.4	8.9	158.1	-
LM bass (age I+)	14.9	85.0	22.5	-	28.4
LM bass (y-o-y)	210.8	239.9	62.5	2,844.6	158.6
Hybrid sunfish	171.0	57.6	134.2	114.9	102.1
Y-O-Y sunfish	493.2	482.6	1,350.6	2,391.9	2,765.8
Yellow perch	408.9	206.6	407.0	416.6	793.4

Growth of Prey Species

Despite the considerable changes that occurred in population structure at Richardson Lake, the only change in growth rates apparently related to the introduction of flathead catfish was for carp. Mean annual increments (TL) for carp increased as much as 72% by the second year after catfish introduction (Table 6). Growth for age III yellow perch (*Perca flavescens*), bluegill and black crappie all improved significantly (t-test, $p < 0.05$) in 1981 but it is not clear that this was related to the introduction of catfish.

The condition of Richardson Lake carp declined after 1978. The slopes of carp length-weight regressions (Fig. 1) calculated from data before and after catfish introduction differed significantly (analysis of covariance, $p < 0.01$). Over the size ranges compared, mean weights of carp were consistently lower following the stocking of flathead catfish.

Although catch indices of prey species remained relatively stable at Dog Lake, positive changes in growth rate were observed for several age classes and species (Table 7). Growth increments for bluegill, black crappie and white crappie age III and IV all improved in 1981, as occurred at Richardson Lake. Conditions in both lakes were apparently favorable for growth during 1981.

Status of Stocked Flathead Catfish

Large-mesh gill nets ultimately were the most successful gear for sampling flathead catfish. Catch rates for flathead catfish ranged from 0.24/30.5 m/24 hr set for 102 mm mesh multifilament nets to 1.12/30.5 m/24 hr set for the 89 mm mesh monofilament gill net. Mortality caused by the gill nets was less than 6% and many individuals were sampled repeatedly.

Table 6. Mean annual growth increments (mm) and percentage changes for Richardson Lake prey species, before (1974-78) and after (1979-81) the introduction of flathead catfish. (Sample sizes in parentheses.)

Age	1974-78	1979	1980	1981	% change from 1974-78 1979	1980	1981
				Carp			
	(115)	(33)	(11)				
I	85.6	127.8	-	-	49.3	-	-
II	67.6	72.9	-	-	7.8	-	-
III	48.3	72.4	83.1	-	49.9	72.0	-
				Bluegill			
	(1,314)	(564)	(497)	(200)			
I	43.2	29.7	33.8	-	-31.3	-21.8	-
II	54.4	52.8	46.2	44.5	- 2.9	-15.1	-18.2
III	36.1	37.8	42.2	55.1	4.7	16.9	52.6
IV	27.7	25.7	25.1	24.9	- 7.2	- 9.4	-10.1
				Black Crappie			
	(736)	(246)	(242)	(116)			
I	57.2	56.6	55.1	49.8	- 1.0	- 3.7	-12.9
II	76.2	67.8	80.3	73.7	-11.0	5.4	- 3.3
III	47.8	43.7	44.5	65.8	- 8.6	- 6.9	37.7
IV	33.8	29.7	25.1	29.7	-12.1	-25.7	-12.1
				Yellow Perch			
	(115)	(31)	(30)	(10)			
I	63.5	55.9	57.7	-	-12.0	- 9.1	-
II	57.4	43.7	60.2	50.0	-23.9	4.9	-12.9
III	29.7	38.1	32.8	46.2	28.3	10.4	55.6
IV	27.2	-	19.6	24.1	-	-27.9	-11.4

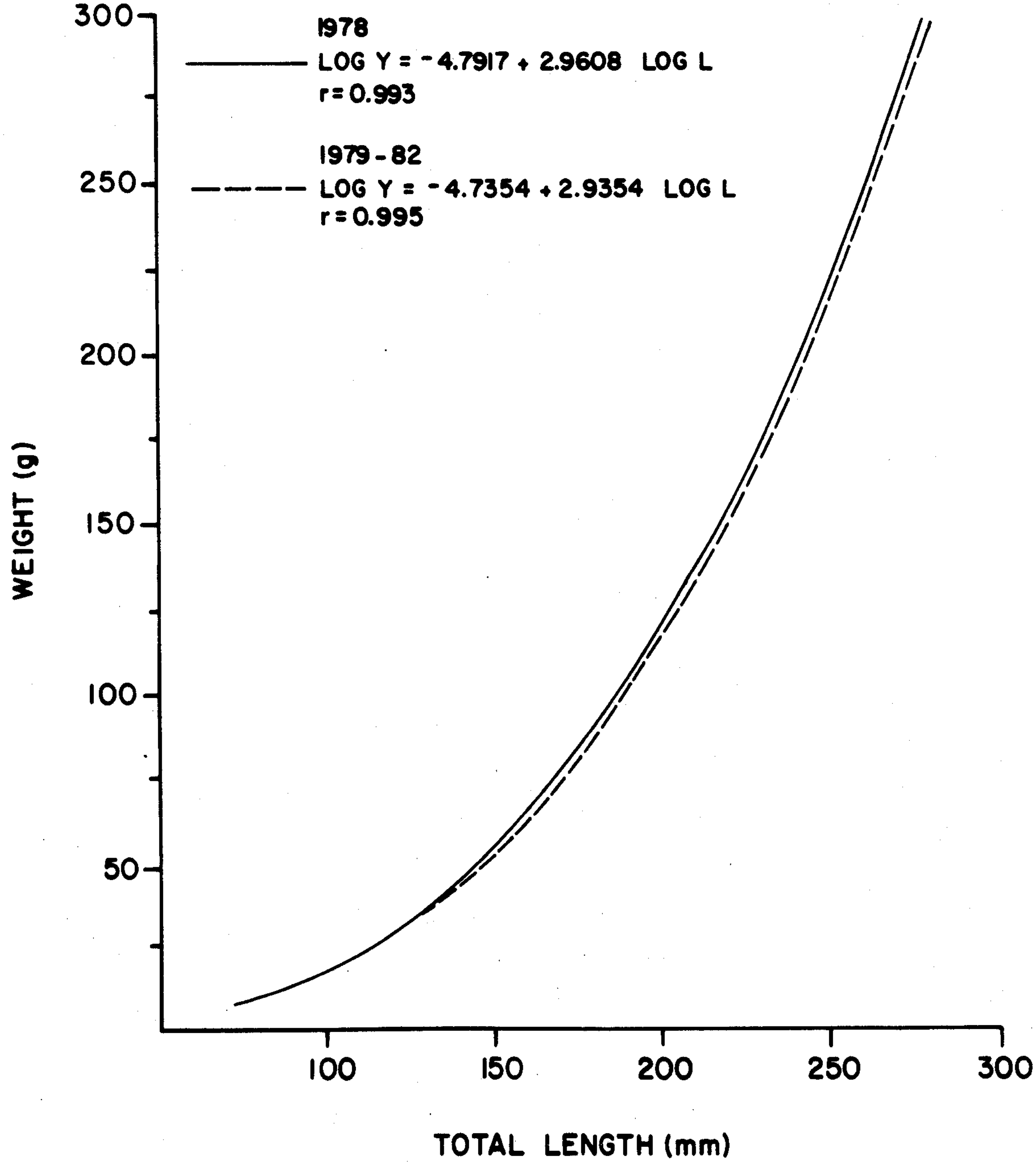

Figure 1. Length-weight relationships of Richardson Lake carp, before and after flathead catfish introduction.

Table 7. Mean annual growth increments (mm) and percentage change for Dog Lake prey species before and after 1979. (Sample size in parentheses.)

					% change from 1974-78		
Age	1974-78	1979	1980	1981	1979	1980	1981
				Carp			
	(409)	(152)	(123)	(99)			
I	32.0	27.9	29.7	29.2	-12.8	- 7.2	- 8.8
II	48.4	41.9	39.9	43.4	-14.1	-18.2	-11.1
III	36.8	38.4	41.4	42.2	4.3	12.5	14.7
IV	20.8	17.8	17.0	24.4	-14.4	-18.3	17.3
				Bluegill			
	(1,342)	(199)	(156)	(97)			
I	38.1	30.0	30.7	35.3	-21.3	-19.4	- 7.3
II	36.3	37.3	42.7	41.7	2.8	17.6	14.9
III	30.0	39.4	41.7	51.1	31.3	39.0	70.3
IV	23.6	28.7	35.8	40.1	21.6	51.7	69.9
				White crappie			
	(622)	(218)	(160)	(89)			
I	45.5	49.3	46.0	58.9	8.4	1.1	29.5
II	67.8	56.9	48.3	72.4	-16.1	-28.8	6.8
III	56.9	58.2	50.3	63.2	2.3	-11.6	11.1
IV	31.2	31.5	40.4	45.5	1.0	29.5	45.8
				Black crappie			
	(823)	(279)	(228)	(124)			
I	46.7	39.9	42.9	-	-14.6	- 8.1	-
II	58.7	61.7	48.8	61.7	5.1	-16.9	5.1
III	42.4	44.2	45.5	58.9	4.2	7.3	38.9
IV	25.9	26.7	34.5	40.4	3.1	33.2	56.0

Survival rates of flathead catfish sufficiently large to be vulnerable to the gill nets were quite high for two years after their introduction. Estimated survival rates for 1980 and 1981 were 0.677 and 0.894, respectively. These estimates are minimal since 28% of the catfish examined had lost their tags.

A majority of the flathead catfish stomachs sampled during 1980-1982 contained food. Of the 63.5% containing food, 69.6% had eaten prey identifiable as fish and 39.1% had eaten fish distinguishable as carp or bullhead (Table 8). Yellow perch, bluegill and crappie remains were present but did not comprise substantial portions of the total. Aquatic vegetation was found in 23.6% of the stomachs but it may have been ingested along with prey rather than chosen deliberately. Insect larvae and other invertebrates were also present in trace amounts.

Table 8. Percent frequency of food items in stomachs of flathead catfish containing food, Richardson Lake, 1980-82.

	Year			1980-82
	1980	1981	1982	combined
Sample size	62	29	83	174
Fish remains (including scales)	71.1	51.6	74.6	69.6
Carp	32.3	10.3	33.7	29.3
Bullhead spp.	11.3	10.3	8.4	9.8
Bluegill	-	-	1.2	0.6
Crappie	-	-	3.6	1.7
Yellow perch	6.5	6.9	2.4	4.6
Unidentified	21.0	24.1	25.3	23.6
Invertebrates	25.8	6.9	16.9	18.4
Vegetation	21.0	10.3	30.1	23.6
Unidentified material	24.2	27.6	15.7	20.7

Relative percentages of different species eaten did not change substantially during the three years except for a decline in the percentage of flathead catfish containing carp in 1981. Bullhead were found in approximately 10% of catfish stomachs in each year, and bluegill and crappie did not appear in the diet of the catfish until 1982.

The few prey fish found relatively undigested were yellow perch and black bullhead from 127-178 mm TL. These were eaten by catfish ranging in weight from 1.3 to 13.6 kg. Two small carp that measured 327 and 333 mm TL and weighed approximately 450 g each were also found in the stomachs of catfish that weighed 1.8 and 2.3 kg.

Electivity index values "E" (Ivlev 1961) were calculated to assess feeding selectivity for the five prey species seen in the stomach samples. Selection for carp was strongly positive, especially in 1980 and 1982 (Table 9). Although black bullhead were found in substantial numbers in catfish stomach samples, selection for them was negative in all three years, particularly 1980. The opposite was true for yellow perch, as "E" values were strongly positive in 1981 and 1982, even though perch were found in only 4.6% of flathead catfish stomachs during these three years. Bluegill and black crappie were found in catfish stomach contents only in 1982 with "E" values being strongly negative for both species.

Growth of flathead catfish was directly related to size at stocking and length of time present in the lake (Fig. 2). Growth was substantially faster for smaller individuals and increased nearly linearly with time ($r = 0.995$). Those larger than 635 mm TL when stocked increased in total length by an average of only a few millimeters within 500 days, although correlation of growth with time was still strongly positive ($r = 0.880$).

Table 9. Electivity index (E) for prey species found in the ration of flathead catfish, Richardson Lake, 1980-1982.

Species	Year sampled 1980	1981	1982
Carp	+0.81	+0.44	+0.84
Black bullhead	-0.53	-0.20	-0.25
Bluegill	-	-	-0.93
Black crappie	-	-	-0.85
Yellow perch	+0.25	+0.75	+0.50

Condition of flathead catfish stocked in 1978 and sampled in subsequent years improved during the study years. The slopes of length-weight regressions differed significantly (analysis of covariance, $p < 0.05$) each year (Fig. 3). Over the size ranges compared, mean weights estimated from the length-weight relationships increased annually.

An age-length relationship for flathead catfish could not be determined with assurance because of the variation in length for a given number of annuli. For example, total lengths ranged from 546 to 813 mm for individuals with six discernable annuli (Table 10). Total lengths for ages V and VII varied nearly as much, with differences up to 206 mm observed for fish of the same apparent age. Although mean TL increased generally with age, variation was such that the difference in TL between individuals with the least (three) and the most (fourteen) observed annuli was only 30 mm.

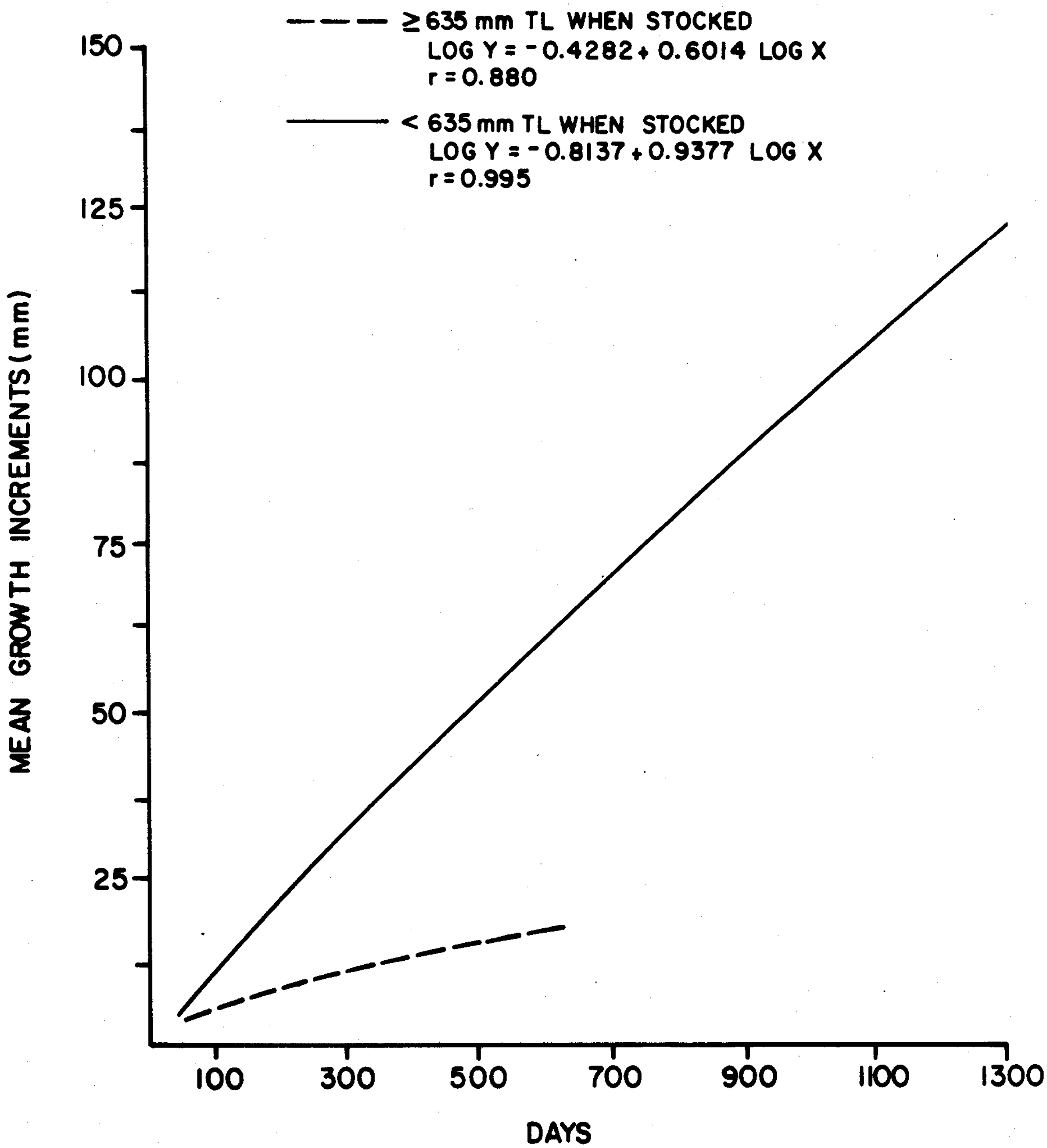

Figure 2. Growth increments of flathead catfish by size at stocking and length of stay in Richardson Lake, 1979-82

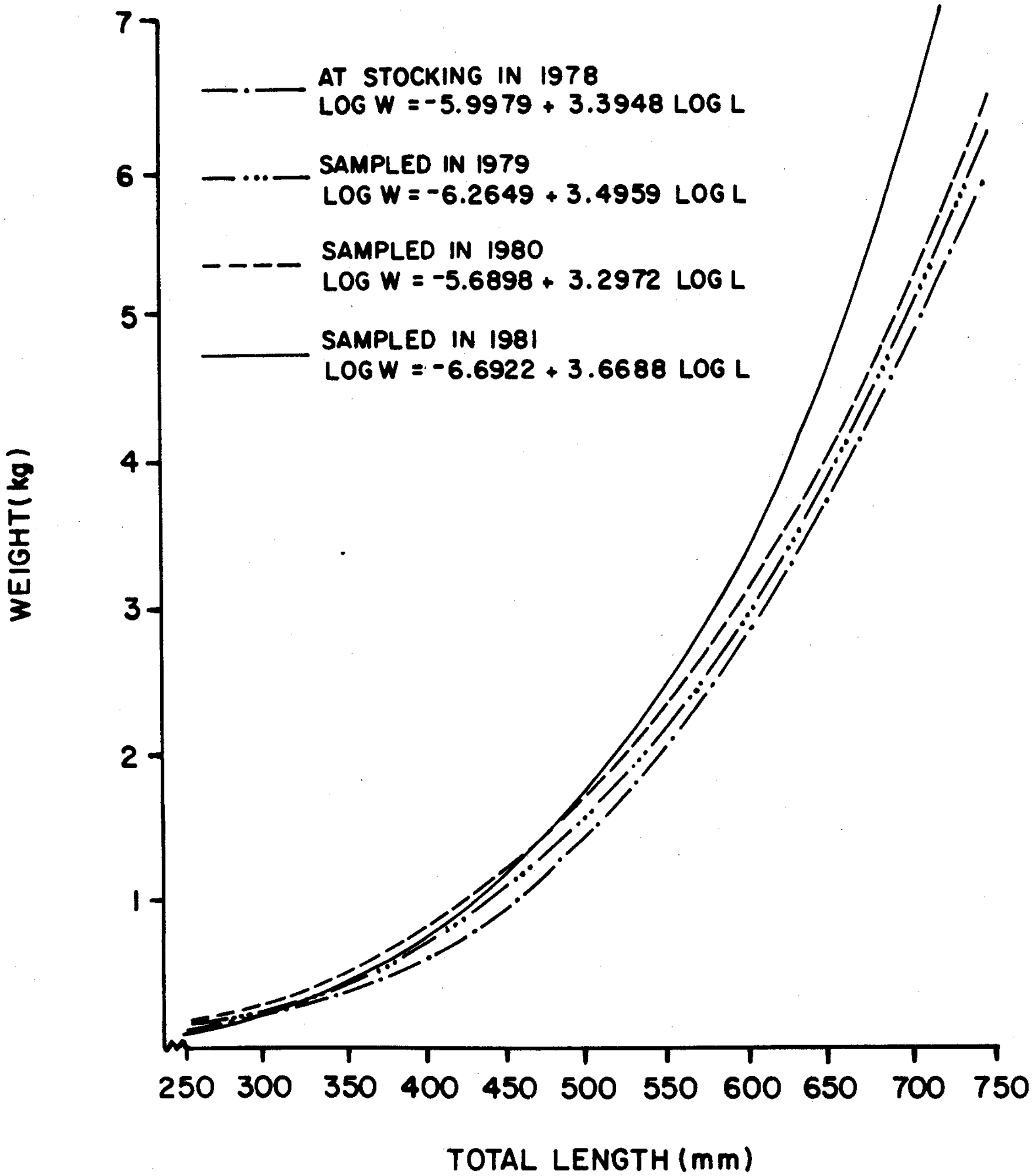

Figure 3. Length-weight relationships of flathead catfish stocked in 1978 and sampled in 1979-81, Richardson Lake.

Table 10. Total lengths (mm) and ages of flathead catfish sampled at Richardson Lake, 1981.

	Age								
	III	IV	V	VI	VII	VIII	IX	X	XIV
n	1	5	17	33	13	7	1	2	1
Total length	681	620	655	650	683	729	843	749	711
Minimun TL	-	452	546	546	638	612	-	719	-
Maximum TL	-	688	752	813	815	879	-	777	-
s^2	-	7,309	2,986	2,418	2,435	8,262	-	841	-
c.v.		0.138	0.083	0.076	0.072	0.125	-	0.039	-

DISCUSSION

Circumstantial evidence strongly suggests that stocked adult flathead catfish effectively reduced carp and bullhead numbers in Richardson Lake within one year. The CPUE for carp declined by 86.5% and the combined CPUE's of the three bullhead species were reduced to less than 10% of their former numbers. During the same year, CPUE remained stable for most species in Dog Lake where no additional predators were stocked. The reductions seen at Richardson Lake were similar to those observed in the Cape Fear River, N.C., within 15 years of a single stocking of 11 adult flathead catfish (Guier et al. 1980). There the flathead catfish became the dominant predator, causing a decline in numbers and percent by weight of all native Ictalurids and the virtual elimination of the brown bullhead.

The decline in Richardson Lake carp and bullhead coincided with their frequent occurrence in flathead catfish stomach contents. They have also been frequently reported in flathead catfish diets from other areas. Turner and Summerfelt (1971) found carp in 23.2 to 42.0% of flathead catfish stomachs from Oklahoma reservoirs. Gholson (1970) found carp to be a major prey of flathead catfish larger than 4.5 kg in the Medina and Rio Grande rivers of Texas and bullhead were prominent in stomach samples from the Cape Fear River (Guier et al. 1980).

Carp and black bullhead appeared to be the preferred prey of flathead catfish immediately after the catfish were introduced into Richardson Lake. Although these two species were substantially reduced in number in 1979, flathead catfish continued to feed on them to the near exclusion of other species. The negative electivity indices calculated for black bullhead were probably sampling artifacts. Olson (1976) observed that black bullhead were less vulnerable to entrapment gear in the summer and fall than in spring. The netting on which the electivity indices for Richardson Lake were based probably doesn't reflect the true relative abundance of black bullhead.

Other investigators have described a variety of preferred prey species. Hackney (1965) and Edmundson (1974) found that centrarchids were chosen over cyprinids while Turner and Summerfelt (1971) observed that carp were preferred over centrarchids and that gizzard shad were selected over all other species. Bamberg (1972) noted that gizzard shad were the favorite prey of flathead catfish in several west Texas lakes.

Most investigators have concluded that selection for larger-sized prey, rather than for species, is more characteristic of flathead catfish as they grow. Gholson (1970) found flathead catfish weighing 4.5 kg that had eaten carp as large as they could swallow and Swingle (1967) felt that fish may compete with the angler for harvestable ($\geq$178 mm TL) bluegill. Larger prey was also utilized at Richardson Lake where several carp weighing 0.4-0.7 kg were found in stomach contents of 1.8 to 2.3 kg flathead catfish. However, small bullhead 127-153 mm TL were also eaten by flathead catfish that weighed up to 9 kg, suggesting that opportunity may ultimately be more important than either size or species in selecting prey.

The improved condition of flathead catfish was an indication of the highly favorable environment they found at Richardson Lake. Mean weights after one or more years in the lake were considerably higher than for flathead catfish from either Bluestone Reservoir, W. Va. (Edmundson 1974) or the Cape Fear River, N.C. (Guier et al. 1980). Whether this was due to habitat-related differences in food availability or less expenditure of energy due to the lack of current in Richardson Lake is a matter of speculation.

The age of flathead catfish from Richardson Lake was difficult to determine with confidence because the fish came from disparate sources as adults and consequently were not stocked at known ages. This precluded verification of age at time of stocking or estimating numbers of missing annuli. Guier et al. (1980) observed that portions or complete annuli were lost with increasing frequency in older age groups which suggests that determination of age in catfish beyond age V or VI is highly uncertain.

Considerable variation existed in age at a particular length. This was also observed for flathead catfish from other locales. For example, age VI individuals from the Verdigris River, OK. averaged 373 mm TL while those from Boomer Lake, OK. had a mean TL of 826 mm (McCoy 1953; Jenkins and Finnell 1957). Mean TL for Richardson Lake catfish were well within these ranges.

MANAGEMENT IMPLICATIONS

The flathead catfish shows considerable potential as a biological control for certain undesirable species. However, stocking them as adults is impractical as a routine management technique because of cost and the difficulty of acquiring them in sufficient numbers. Stocking them as y-o-y (fingerling) or yearlings (advanced fingerling) may be more feasible and should be evaluated.

More investigation is necessary before flathead catfish can be used routinely for management purposes in Minnesota. Considerable information is needed concerning optimum fingerling stocking rates and sizes under various conditions, the sizes of lakes in which fingerling stocking would be feasible and the types of unbalanced fish populations that flathead catfish might be able to impact. A study is currently in progress to examine these factors so that more specific guidelines can be formulated for the proper use of fingerlings.

The expense and difficulty of raising flathead catfish fingerlings to large size in Minnesota latitudes (needed to reduce vulnerability to predation) suggests that they should probably be stocked as yearlings. After two growing seasons, they should have grown to 177-203 mm, so there would be some delay between stocking and a measurable impact on the target species. If stocked after one growing season (y-o-y), this delay would be one year longer and survival of the fingerlings would be less certain, although cost would be reduced. Trade-offs of this sort would have to be considered when comparing the relative costs of holding catfish over winter to stocking them at a later date.

Another unresolved concern is the possibility that flathead catfish may be able to reproduce naturally in lakes and multiply to nuisance proportions. Although there was no evidence of successful reproduction in Richardson Lake, the possibility has not been conclusively ruled out. Only one instance was found in the literature where introduced flathead catfish multiplied to the point of eliminating another species. However, indiscriminate stocking should be avoided, especially in lakes with inlets or outlets.

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