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Robert D. Walker

K. D. Carlander

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ROBERT D. WALKER and K. D. CARLANDER

Abstract. Channel catfish were held in 18-cubic-foot pens from June 1 to Sept. 9 at stocking rates of 2, 4, 8, 12, 18, and 24 fish per pen. Mean weight per fish on Sept. 9 showed an inverse relationship with population density. Condition factors increased in all pens throughout the study. Fish in pens with 2, 4, and 8 fish were in better condition then those in more crowded pens after July 15. Growth of fish in the pen with 2 fish was similar to that in the open pond. Growth of channel catfish was greater in 2 ft. of water than at 4 and 6 ft. Low dissolved oxygen at 6 ft. caused the death of channel catfish by July 1.

Population density is often the most important factor controlling the average growth rates of fish in various bodies of water. In the summer of 1969, increasing numbers of channel catfish were placed in a series of wire enclosures in a farm pond to demonstrate the effect of population density.

DESCRIPTION OF AREA

The pond used in this study was located 3.5 miles (5.6 km) northeast of Ames on the Max Bailey farm. It was built in the summer of 1955 as a source of water for livestock and fire control. The only influent to the lake is run-off. Corn dominates the watershed, but there are some small trees and grasses surrounding the lake.

A contour map was made from 40 soundings taken in February 1969. The maximum depth was 13.3 ft. (4 m), with an average depth of 6 ft. (1.8 m). The surface area was 0.72 acres (0.29 ha), and the volume was 4.34 acre ft. (5,350 m^3).

Although largemouth bass, bluegill, and black bullheads were originally stocked, oxygen depletion because of dense ice and snow cover have eliminated all but the bullheads. Channel catfish and tilapia were introduced during the summer of 1969. Rotenone was applied on Oct. 1, 1969. The standing crop of the lake was 1800 lb/acre (2018 kg / ha), the highest recorded in Iowa to date (Carlander and Moorman, 1956).

Invertebrates found in the pond included: Chironomidae and Heleidae of the order Diptera, 1 species of Ephemeroptera, 8 rep-

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resentatives of Zygoptera and Anisoptera of the order Odonata, several species of oligochaetes, 1 nematode, 1 pelecypod and 2 gastropods, 1 coleopteran, and several hemipterans. Aquatic plants included Coontail, *Ceratophyllum demersum,* and Cladophora. The pond was thermally stratified throughout the summer, and dissolved oxygen decreased rapidly between 3 and 6 feet from the surface.

Care of Channel Catfish

The channel catfish used were obtained from the Federal Fish Culture Research Center at Stuttgart, Ark. They arrived at Iowa State University on May 9, 1969, and were in good condition. The fish were held in a metal tank, 7 ft. long, 2 ft. wide, and 2 ft. deep. Total water volume was 28 cubic ft. or 196 gallons. Decholorinated water was used and held at temperatures near 21° C. The fish were fed Purina Trout Chow every other day. Of 450 fish in the tank, only 1 died before they were stocked on May 29, 1969.

The coefficient of condition, K

which equals W/L^3 (10^5)

when : W = weight in grams

and L = total length in millimeters

was calculated for each fish.

All fish were marked with a fin clip. Those in the pens were marked with various combinations of 1, 2, or 3 clipped fins so that each individual could be identified. Those turned loose in the lake were marked with a combination of 2 clipped fins corresponding to 1 of 4 original size groups. Immediately after clipping, the exposed tissue was cauterized to prevent fin regeneration (Chadwick, 1966).

Pens were made with ½-inch hardware cloth stapled on wooden frames measuring 3 x 3 x 3 ft. Six pens were set at a depth of 2 ft. and stocked with 2, 4, 8, 12, 18, and 24 catfish each, May 29, 1969. Lengths and weights were taken on these fish biweekly.

Growth at Various Densities

On June 17, 8 fish with columnaris were observed in the pens. According to Davis (1967), optimum temperatures for this bacterial disease are 25° - 27° C., 16° being the minimum tolerable temperature. The water temperature in the Bailey pond at this time was 22° C., well within the tolerable limits. One week later, the water temperature dropped to 19.5° C., and the columnaris disappeared. This reduction in temperature was evidently enough to suppress the disease. The loss of 4 fish by July 1, 1 from pen

Table 1. Number, average weight, average length and biomass of channel catfish in population density pens checked at 2-week intervals.

	June 3	June 17	July 1	July 15	July 29	Aug. 12	Aug. 26	Sept. 9
Pen #2								
Number	2	2	2	2	2	2	2	2
Average weight	4.0	6.0	8.5	18.0	21.5	30.0	32.0	39.0
Average length	99.0	108.0	116.0	129.0	150.0	162.0	170.0	180.0
Biomass	8.0	12.0	17.0	36.0	43.0	60.0	64.0	78.0
Pen #4								
Number	4	4	4	4	4	4	4	4
Average weight	3.8	5.9	7.4	9.5	12.2	14.6	15.0	17.2
Average length	96.0	104.8	108.2	112.5	123.5	129.8	129.8	135.0
Biomass	15.2	23.6	29.6	38.0	48.8	58.4	60.0	68.8
Pen #8								
Number	8	8	7	8	8	8	8	8
Average weight	9.8	10.0	12.5	12.0	12.1	13.4	14.8	16.3
Average length	112.7	116.0	117.7	118.9	118.2	121.5	122.8	127.8
Biomass	78.4	80.0	87.5	96.0	96.8	107.2	118.4	130.4
Pen #12								
Number	8	11	11	11	11	11	9	9
Average weight	5.9	5.1	6.2	5.9	7.0	8.0	8.7	10.1
Average length	102.5	103.4	104.0	105.4	106.4	108.7	109.9	114.2
Biomass	47.2	56.1	68.2	64.9	77.0	88.0	78.3	90.9
Pen #18								
Number	18	18	15	18	17	17	17	17
Average weight	5.0	5.0	4.1	4.9	5.3	6.1	6.9	8.9
Average length	98.1	99.8	100.3	100.9	101.7	103.0	104.2	109.5
Biomass	90.0	90.0	61.5	88.2	90.1	103.7	117.3	151.3
Pen #24								
Number	23	23	23	22	21	21	20	20
Average weight	6.0	5.6	5.0	4.8	6.0	6.9	7.2	7.9
Average length	101.5	104.2	104.3	104.3	105.3	106.0	106.8	108.2
Biomass	138.0	128.8	115.0	105.6	126.0	144.9	144.0	158.0

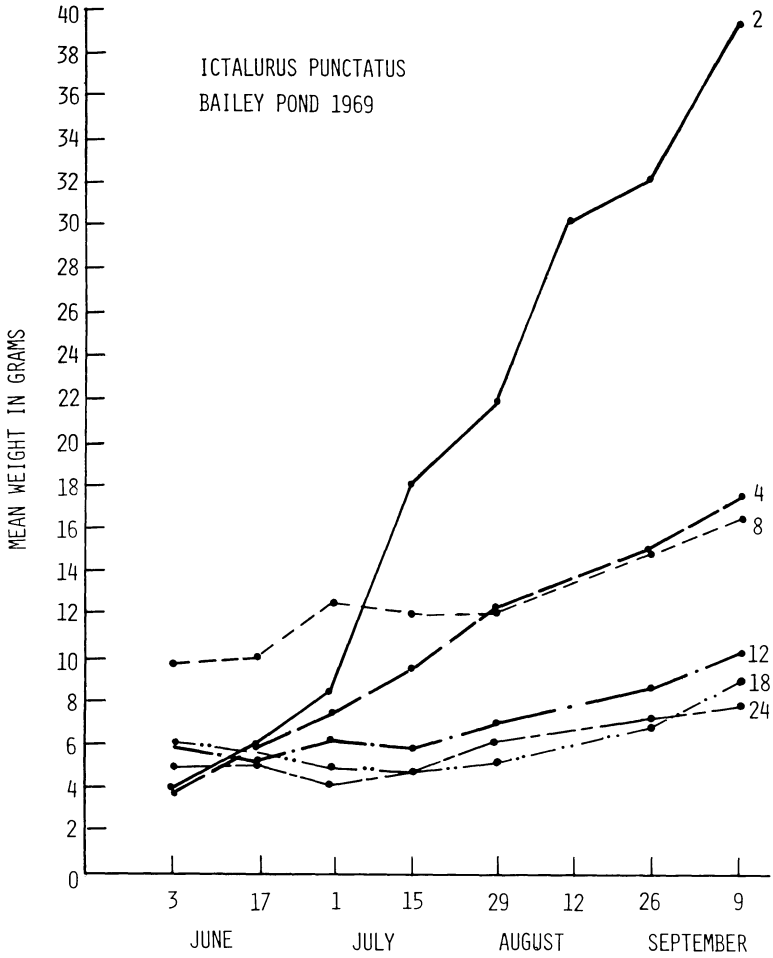

Fig. 1. Mean weight of channel catfish in cages with 2, 4, 8, 12, 18, and 24 fish.

#8 and 3 from pen #18, was attributed to columnaris. These fish were replaced immediately, as were losses from pens 12 and 24 before July 1. After this no fish were added to compensate for losses.

The effects of low density can be seen by the greater average growth rate in the pen with 2 fish throughout the study (Table 1). On Sept. 9, 1969, the mean weight per fish showed an inverse relation to density level (Fig. 1), although the pen with 20 fish showed the greatest biomass. The biomass in all pens increased throughout the study, indicating that the maximum standing crop was not attained.

Table 2. Average condition factors of channel catfish in pens of various density levels at 2-week intervals. (Number of fish as in Table 1)

Pen #	June 3	June 17	July 1	July 15	July 26	Aug. 12	Aug. 26	Sept. 9
2	.41	.48	.54	.84	.64	.71	.65	.67
4	.42	.46	.58	.67	.68	.68	.69	.70
8	.42	.46	.45	.56	.62	.62	.70	.70
12	.50	.43	.47	.48	.56	.59	.64	.66
18	.51	.49	.35	.46	.49	.56	.61	.66
24	.55	.46	.38	.40	.50	.57	.59	.61

When the fish were stocked on May 29, those in pens 12 to 24 were evidently heavier for their lengths than those in pens 2 to 8, if we are to judge by the condition factors on June 3 (Table 2).

After June 17, the average condition per pen was greatest for either 2 fish or 4 fish except on Aug. 26 when the pen with 8 fish had the greatest condition. This factor was not consistently greatest for the pen with 2 fish as was expected. In nearly all instances, the average condition per pen increased throughout the summer for the pens with 2, 4, 8, and 11 fish. The pens with 18 and 23 fish showed a loss in condition through July 1, followed by a steady increase in condition throughout the rest of the study.

Growth at Various Depths

To compare growth at depths of 2, 4, and 6 ft., 2 fish were confined in pens at each of these depths. It was assumed that production would be greatest in the pen in shallow water because of food, light, temperature, and chemical characteristics of water. The mean weight and biomass were greatest throughout the summer in the pen in 2 ft. of water (Table 3). The average condition of fish in these pens showed no relationship with the depth.

The 2 fish at the 6-ft. depth died between July 1 and July 15. This was attributed to low dissolved oxygen below 3 ft. On July 8, the surface reading was 5.7 ppm, and there was a definite oxygen stratification throughout the study. From June 17 through July 1, these fish did show an increase in mean condition and biomass, but the changes were not as great as those in 2 and 4 ft. of water.

Growth in the Pond

On May 29 when the pens were stocked, 265 catfish fingerlings were released in the pond. The fish were finclipped according to size group (Table 4). They ranged from 2 to 24 g and averaged 5.4 g.

Table 3. Average condition factors, average weight, average length, and biomass of channel catfish at 2, 4 and 6 ft. depths.

	Date							
	6-3	6-17	7-1	7-15	7-29	8-12	8-26	9-9
2 Fish at 2 ft.								
Mean K	.41	.48	.54	.84	.64	.71	.65	.67
Mean weight	4.0	6.0	8.5	18.0	21.5	30.0	32.0	39.0
Mean length	99.0	108.0	116.0	129.0	150.0	162.0	170.0	180.0
Biomass	8.0	12.0	17.0	36.0	43.0	60.0	64.0	78.0
2 Fish at 4 ft.								
Mean	.51	.52	.54	.64	.71	.74	.72	.75
Mean weight	4.0	5.5	7.0	9.5	15.0	22.0	27.0	31.2
Mean length	92.5	101.5	109.9	114.0	128.5	144.4	153.0	161.0
Biomass	8.0	11.0	14.0	19.0	30.0	44.0	54.0	62.4
2 Fish at 6 ft.								
Mean K		.56	.60					
Mean weight		6.5	7.5					
Mean lengh		104.5	106.5					
Biomass		13.0	15.0					

Table 4. Growth of channel catfish free in Bailey pond.

		Original size group				
		73-90mm	91-110mm	111-130mm	131-?	
	Number Stocked	44	156	51	18	
	Mean weight	2.5	3.9	8	18	
June 1	Mean length	87.6	98.5	118.3	148.6	
	K Range	.27-.51	.32-.53	.34-.61	.48-.63	
	Mean K	.38	.41	.48	.55	
	Number Returned	24	62	21	13	118 Total
Sept. 26	Mean weight	31.7gr	37.5gr	46.5gr	63.8gr	
to	Mean length	161.5mm	171.8mm	188mm	207.8mm	
Oct. 4	K Range	.64-.96	.65-.96	.63-.73	.61-.77	
	Mean K	.75	.74	.70	.71	
	Percent return	54.5%	39.7%	41.2%	72.2%	

Table 5. Growth in length of channel catfish in second growing season in Bailey Pond compared with Iowa River (Harrison, 1957).

	Size at beginning of growing season	Growth (mm)
Bailey Pond	103.6	74
Des Moines River	76.2	66
Cedar River—Vinton	81.3	53
Mississippi River—Sabula	83.8	109
Little Sioux River	71.1	109

A seine and electric shocker were used to recover fish from the pond from Sept. 16 through Sept. 27. The seine proved more effective. On Oct. 1, the pond was treated with rotenone. The total number of catfish captured was 238 or 90% of those stocked. Fish were in the pond 119-125 days.

The mean weight of 265 channel catfish stocked on May 29, 1969, was 5.4 g, the range being 2 - 24 g. The length-weight relationship determined from the May 29 date was Log. W = –5.64 + 3.17 Log. L. This relationship, calculated on Oct. 1, was Log. W = –4.33 + 2.64 Log. L. In October, the longer fish were relatively thinner than the shorter fish of the same age. The mean weight of 167 channel catfish collected Oct. 1, 1969, was 41.4 g with range of 18-95 g, for a growth of 36 g per fish. The fish that were larger when stocked showed the greatest gain in weight while the smaller fish showed a greater increase in condition (Table 4).

The standing crop of the 238 catfish collected Oct. 1, was 21.66 lb or 30.08 lb per acre (33.7 kg per hectare).

Discussion

The increase in length of the yearling catfish in the pond was greater than in the Des Moines or Cedar River, but less than in the Little Sioux or Mississippi River (Table 5). The average length of the stocked catfish was greater than at the beginning of the growing season in the rivers. Since annual growth in length is usually less for longer fish, the growth in the pond seems to have been above average. On the basis of the area of pond, each individual catfish at liberty had about 30 times as much area as each catfish in the enclosures with 2 catfish. The growth rate of the catfish in these pens was about the same as that of the catfish at liberty.

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