EFFECTS OF CROPPING ON GROWTH OF CHANNEL CATFISH

WILLIAM W. STEPHENS, Box 166, Belzoni, MS 39038
JOHN K. BEADLES, Department of Biology, Arkansas State University, State University, AK 72467

Abstract: From 20 May to 28 October 1978, 5 experimental fish ponds at Arkansas State University Fish Farm, Walcott, Arkansas, were utilized in determining the effects of cropping on channel catfish growth. Three ponds were used as experimental ponds and 2 as controls. Selected physiocochemical properties of the water were measured. With the exception of air and water temperatures, properties of the experimental ponds fluctuated more than the controls due to indirect effects of cropping. However, all values fell within acceptable ranges for channel catfish (*Ictalurus punctatus* Rafinesque) culture. Mean biweekly gains for the experimental and control fish were .065 and 0.63 kg respectively. Analysis of variance and t-test analysis indicated that at an innitial stocking density of 3720 fish per ha, cropping yielded no significant differences in growth rate or weight gain.

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Swingle (1958) developed much of the early culture technique for channel catfish production. Although many well documented advances have been made (U.S. Bureau of Sport Fisheries and Wildlife 1973; Lewis and Sheehan 1976; Snow 1976; and Lovell et al. 1978), the basic approach utilized by Swingle (1958) has remained the same.

Studies on the effects of cropping (periodic removal), however, are limited. Allen (1974) studied the results of selective cropping versus batch cropping in raceway culture. Snow (1976) referred to cropping as periodic division of the stock, but his attempts were an effort to maintain a standing crop of 2270 kg per ha. The design was hypothetically divided into 4 phases of growth with an initial stocking rate of 20,000 fish, 12.7 cm in length, per .4 ha. They were fed at a rate of 3% body weight with an assumed feed conversion of 1.3 and with a change in amount of feed every 2 weeks. Another application of the cropping technique (Lovell et al. 1978) was studied in which harvestable fish were periodically removed and smaller fish restocked.

The .68 ha rectangular ponds used in this study are part of a series of 11. These have a minimum depth of .61 m in the shallow end and 1.52 m in the deep end. The ponds received water from a 20.32 cm well. Maximum wind action was assured by the absence of trees.

Recognizing that growth rate in conjunction with numerical density determines the production capability or culture worth of a species, it was the purpose of this study to investigate the effects of multiple cropping through the growing season on growth rates and weight gains. Perhaps information obtained from this study would be a useful managerial tool for intensive fish culturists.

MATERIALS AND METHODS

The 5 Arkansas State University ponds involved in this study are located near Walcott, Greene County, Arkansas (T16N, R4E, Sec. 7, and NW1/4). Greene County lies within the alluvial valley of the Mississippi River, which begins near Cape Girardeau, Missouri, and extends southward as far as the head of the Atchafalaya River in Louisiana, where the delta plains begin. The width of the valley varies from 40 km near Natchez, Mississippi, to 201 km near Helena, Arkansas. A thick veneer of loess overlies the bedrock of the valley walls, particularly on the east side (Thornbury 1965).

Ponds 2, 6, and 7 were selected as experimental (cropping) ponds; 5 and 8 were selectd as controls (non-cropping). Two thousand five hundred fish weighing 5.4 kg per 1000 were stocked in each of the 5 ponds on 14 April 1977. Fish and water quality samples were taken biweekly (except fish on 1 July, physicochemical on 19 August, and fish on 23 September) from 20 May through 28 October 1978. Fish were hand-fed from the north levee of each pond at a rate of 3% of fish body weight 7 days a week with Monarch brand (Pocahontas, Ar. 72455) sinking ration (30% protein, 8% carbohydrate, 3% fat, and 11% crude fiber). Feeding rates were adjusted according to sample weights taken.

Physicochemical Determinations

Physicochemical properties were measured at pondside on the south levee between 0600 and 0800 hours. Dissolved oxygen was determined by the sodium azide modification of the Winkler method (APHA 1947) utilizing a Hach kit (Hach Chemical Co., Box 907, Ames, Iowa, 50010). Carbon dioxide and methyl orange alkalinity determinations followed standard limnological methods (Welch 1948). Hydrogen ion cencentration was measured with a standard Taylor colorimeter, and temperature was determined by a standard Celsius thermometer.

Fish Sampling and Removal

Seining occurred between 0800 and 1700 hours and was accomplished by use of two 45.75 X 1.83 m seines with a 2.54 cm bar measure mesh. Mean weights and fork lengths were determined from a minimum of 100 and 25 fish, respectivley, from each pond. When the standing crop in the experimental ponds exceeded 1702 kg per ha, those fish weighing .681 kg and larger were selectively removed.

Data Analysis

Arithmetic means of physicochemical determinations, fish weight and length, and weight gain were computed as experimental data for ponds 2, 6, and 7 and control data for ponds 5 and 8.

The data were analyzed by building computer files for each data category. Analysis of variance was computed for weight gains between experimental and control fish, following the method of Runyon and Haber (1977).

Computer files were then accessible for use with Minitab (Ryan et al. 1976). Routines used in this study were: PLOT, which gives a scatter plot of the data given in columns for physicochemical properties, length and weight rates of growth, and weight gains versus sampling time for ecperimental and control determinations; MPLOT, which produces several plots on the same axes to show relationships between experimental and control data for physicochemical prperties, length and weight rates of growth, and weight gain versus sampling time; CORR which gives the linear correlation between mean length and weight of the experimental and control fish; REGR, which gives the regression equations for the line of best fit in predicting weight from length in both experimental and control fish; and POOL, which computes the T-ratio for signficiant differences between the average gain in weight in the experimental and control fish.

RESULTS

Physicochemical properties (Tables 1 and 2) were seasonally characteristic and fell within acceptable ranges for intensive culture situations (Lee 1973).

Mean dissolved oxygen concentrations ranged from a high of 8.7 pm on 2 September to a low of 3.3 ppm on 24 June and 9 July in the experimental ponds and from a high of 7.0 ppm on 2 and 30 September to a low of 5.5 ppm on 24 June, 23 July, and 5 August in the control ponds (Tables 1 and 2).

Mean carbon dioxide levels in the experimental ponds varied from 13.3 ppm on 9 July to 2.8 ppm on 2 September and from 15.0 ppm on 9 July to 3.5 ppm on 27 May and 11 June in the controls (Tables 1 and 2).

TABLE 1. Mean physicochemical determinations of experimental ponds, 27 May - 27 October 1978.

Sample Date	pH	Oxygen (ppm)	Carbon Dioxide (ppm)	Alkalinity M.O. (ppm)	Temperature Air (C)	Temperature Water (C)
5-27	7.4	6.0	7.7	97.0	27.7	27.0
6-11	7.7	6.7	3.2	98.0	22.2	23.5
6-24	7.1	3.3	7.7	95.0	25.7	25.0
7-09	7.1	3.3	13.3	99.0	29.3	27.3
7-23	7.6	7.3	4.0	88.5	27.3	28.2
8-05	7.1	4.0	8.0	97.3	19.3	29.0
9-02	7.7	8.7	2.8	86.7	18.5	23.0
9-16	7.2	3.7	8.2	103.3	24.0	25.2
9-30	7.1	4.0	10.8	77.3	12.2	20.2
10-16	7.8	7.0	5.2	76.7	7.8	13.2
10-27	7.6	7.3	4.5	71.7	7.8	14.0

TABLE 2. Mean physicochemical determinations of control ponds, 27 May - 27 October 1978.

Sample Date	pH	Oxygen (ppm)	Carbon Dioxide (ppm)	Alkalinity M.O. (ppm)	Temperature Air (C)	Temperature Water (C)
5-27	8.0	6.0	3.5	99.0	28.3	27.3
6-11	7.7	6.5	3.5	87.5	24.3	23.8
6-24	7.3	5.5	6.8	90.5	25.8	25.0
7-09	7.1	6.0	15.0	88.5	30.5	27.5
7-23	7.3	5.5	8.0	90.0	28.0	28.0
8-05	7.2	5.5	5.6	91.5	19.3	27.0
9-02	7.2	7.0	7.5	80.0	18.5	22.0
9-16	7.2	-	10.0	90.0	24.5	25.0
9-30	7.0	7.0	8.5	75.0	14.0	20.0
10-16	7.8	-	5.0	75.0	10.0	14.0
10-27	7.3	6.0	5.0	75.0	13.0	14.5

Mean pH values ranged from a high of 7.8 on 16 October to a low of 7.1 on 24 June, 9 July, 5 August, and 30 September in the experimental ponds and from a high of 8.0 on 27 may to 7.0 on 30 September in the controls (Tables 1 and 2).

Mean concentrations of methyl orange alkalinity varied from 103.3 ppm on 16 September to 71.7 ppm on 27 October in the experimental ponds and from 99.0 ppm on 27 May to 75.0 ppm on 30 September, 16 October, and 27 October in the controls (Tables 1 and 2). Phenolphthalein alkalinity was never present.

Temperatures in both experimental and control ponds varied seasonally and with air temperatures, and mean values ranged from 13.3C on 16 October to 29.0C on 5 August (Tables 1 and 2).

With the exception of air and water tempertures, physicochemical properties of the experimental ponds fluctuated more than in the controls (Figs. 1-6).

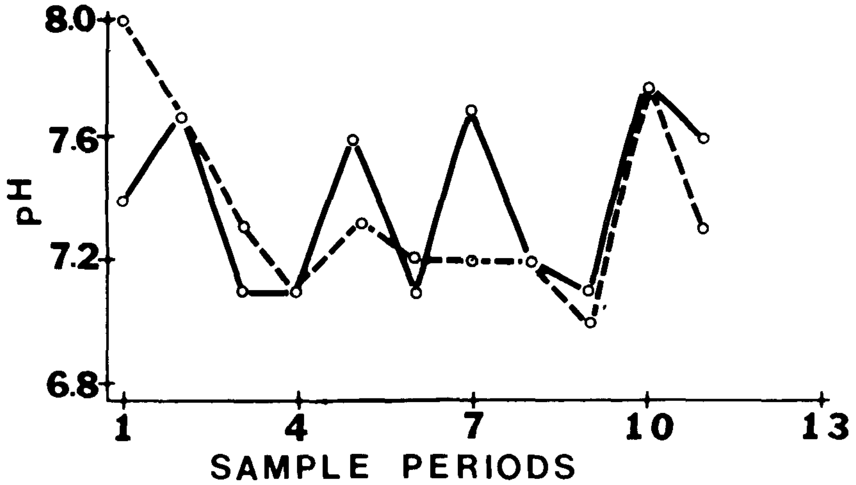

Fig. 1. -Mean biweekly variation of pH in experimetal (sold line) and control (broken line) ponds.

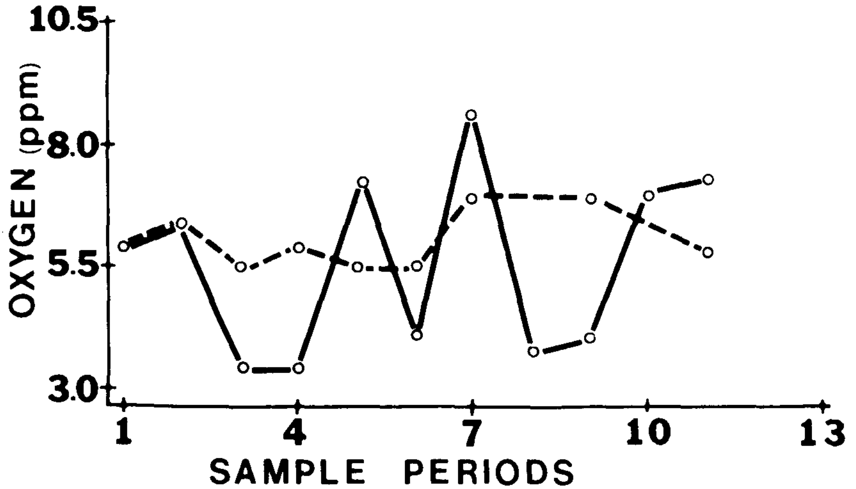

Fig. 2. -Mean biweekly variation of oxygen in experimental (solid line) and control (broken line) ponds.

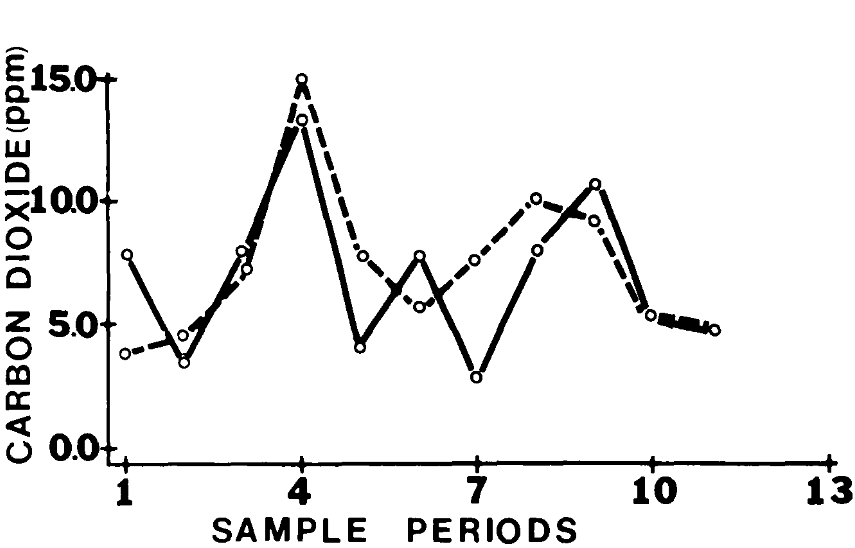

Fig. 3. -Mean biweekly variation of carbon dioxide in experimental (solid line) and control (broken line) ponds.

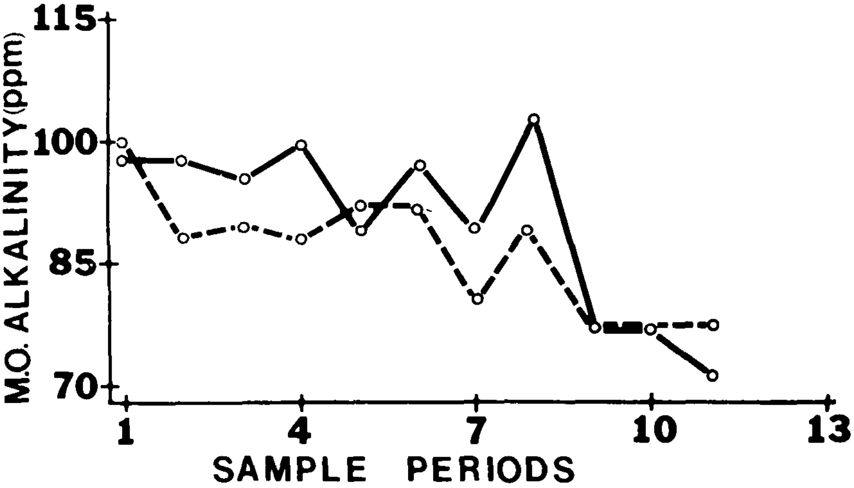

Fig. 4. -Mean biweekly variation of methyl orange alkalinity in experimental (solid line) and control (broken line) ponds.

Extensive loss of fish in ponds 5 (control) and 2 (experimental) occurred on 23 August and 23 September. The loss had no effect on the results of the study and subsequent data on the 2 were not recorded.

Cropping produced no significant differences ($P \geqslant 0.05$) in growth rate or weight gain (Tables 3-6) as was statistically revealed by analysis of variance and t-testing. Mean biweekly gains for the experimental and control fish were 0.65 and 0.63 kg, respectively. The variance in biweekly gains for the control fish (.00511), although somewhat higher than the variance in the gains for the experimental fish (.00298), F-ratio 1.71, was not

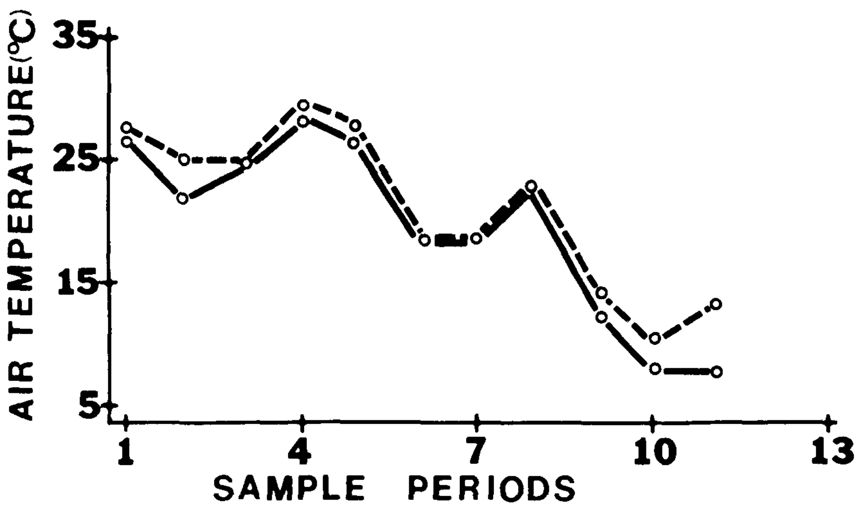

Fig. 5. -Mean biweekly variation of air temperature in experimental (solid line) and control (broken line) ponds.

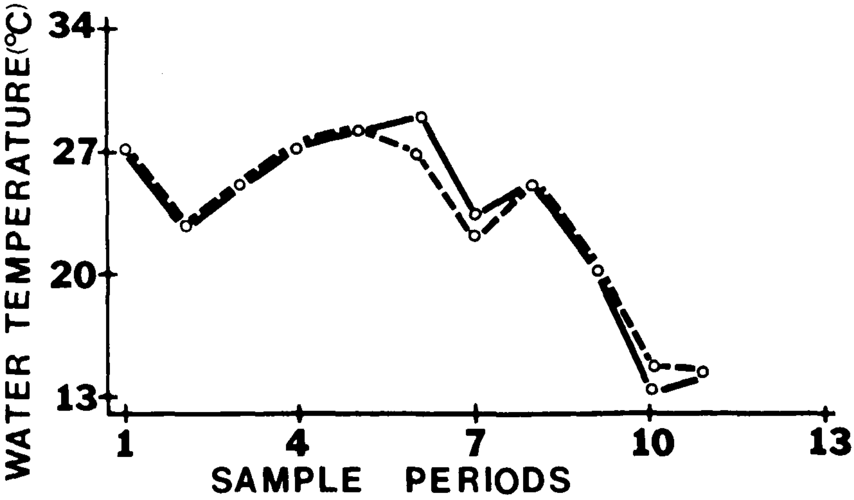

Fig. 6. -Mean biweekly variation of water temperature in experimental (solid line) and control (broken line) ponds.

significantly different at the .05 confidence level. T-testing substantiated the lack of significant difference revealed by analysis of variance.

Experimental and control fish exhibited a parallel rate of growth in weight and lengths (Figs. 7 and 8), but there was a four-week lag period in the weight gain among control fish (Fig. 9). Good correlation was demonstrated between mean weights and lengths ($r=.963$, $P\geqslant0.05$, and $d.f.=8$; $r=.982$, $P\geqslant0.05$, and $d.f.=8$) in experimental and control fish, respectively (Figs. 10 and 11).

TABLE 3. Mean weight and weight gain of experimental fish expressed as kg/ individual, 20 May - 28 October 1978.

Sample Date	POnd 2	Pond 6	Pond 7	Experimental Mean	Experimental Gain
5-20	.431	.386	.377	.398	-
6-03	.415	.427	.431	.424	.026
6-17	.490	.402	.445	.446	.022
7-15	.577	.459	.554	.530	.084
7-27	-	.518	.522	.520	-.010
8-12	.867	.572	.631	.690	.170
8-26	1.007	.708	.658	.791	.101
9-09	.876	.785	.722	.794	.003
10-07	-[a]	.926	.831	.879	.085
10-28	-	.953	.981	.967	.088

[a]After 23 September pond 2 was deleted from study due to fish kill.

TABLE 4. Mean weight and weight gain of control fish expressed as kg/individual 20 May - 28 October 1978.

Sample Date	Pond 5	Pond 8	Control Mean	Control Gain
5-20	.359	.259	.309	-
6-03	.380	.314	.347	.038
6-17	.472	.322	.397	.050
7-15	.436	.386	.411	.014
7-27	.436	.397	.416	.005
8-12	.554	.424	.489	.073
8-26	-[a]	.554	.554	.065
9-09	-	.740	.740	.186
10-07	-	.713	.713	-.027
10-28	-	.881	.881	.168

[a]After 23 August pond 5 was deleted from study due to fish kill.

DISCUSSION

The differences in physicochemical fluctuation between experimental and control ponds were an indirect effect of cropping. This biweekly procedure resulted in an increased handling of fish for prolonged periods of time. Although the experimental and control fish were treated the same in every other respect, increased handling, including holding time, was a direct result of cropping. As the fish increased in size, relative feed amounts were increased. Thus, there was an apparent extended lapse of time before the experimental fish would resume feeding. This delay, due to the stress of being handled too much during hot summer months, resulted in extra amounts of unutilized feed in the experimental ponds. This in turn tended to increase the organic load, thus causing greater

TABLE 5. Mean length and length gain of experimental fish expressed as cm/individudial, 20 May - 28 October 1978.

Sample Date	Pond 2	Pond 6	Pond 7	Experimental Mean	Experimental Gain
5-20	29.46	29.08	26.67	28.40	-
6-03	31.24	29.79	31.37	30.80	2.40
6-17	31.37	30.58	30.00	30.65	-.15
7-15	35.43	33.63	35.38	34.81	4.16
7-27	-	31.75	34.54	33.15	-1.66
8-12	39.62	33.02	34.54	35.73	2.58
8-26	38.99	35.05	34.37	36.14	.41
9-09	40.64	37.62	38.68	38.98	2.84
10-07	-[a]	41.28	38.81	40.03	1.05
10-28	-	42.49	38.66	40.58	.55

[a]After 23 September pond 2 was deleted from study due to fish kill.

TABLE 6. Mean length and length gain of control fish expressed as cm/individual, 20 May - 28 October 1978.

Sample Date	Pond 5	Pond 8	Control Mean	Experimental Gain
5-20	28.97	24.67	26.82	-
6-03	30.02	26.31	28.17	1.35
6-17	33.40	27.53	30.47	2.30
7-15	31.37	30.18	30.78	.31
7-27	31.50	28.19	29.85	-.93
8-12	32.00	32.77	32.39	2.54
8-26	-[a]	32.64	32.64	.25
9-09	-	35.59	35.59	2.95
10-07	-	35.86	35.86	.27
10-28	-	38.71	38.71	2.85

[a]After 23 August pond 5 was deleted from study due to fish kill.

fluctauations of pH, O_2, CO_2, and alkalinity. However, at all times, values for physicochemical properties fell within acceptable ranges for channel catfish culture (Lee 1973).

It was thought that the loss of fish in experimental pond 2 and control pond 5 would bias the data. However, a trend had already been established by the end of week 12 (6th sample period) in both experimental and control fish populations (Figs. 7-9). These parallel trends continued after the fish kill; therefore, it was concluded that loss of fish in ponds 2 and 5 had no significant effect upon the outcome of the study.

Loss of fish in the 2 ponds was due to a combination of several contributing factors: heavy phytoplankton bloom with subsequent die-off; high temperatures; little or no

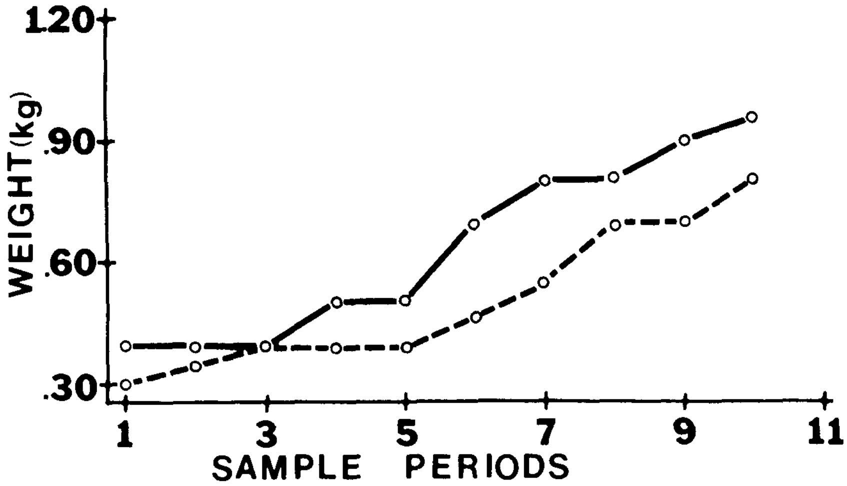

Fig. 7. -Mean biweekly growth rate of experimental (solid line) and control (broken line) fish.

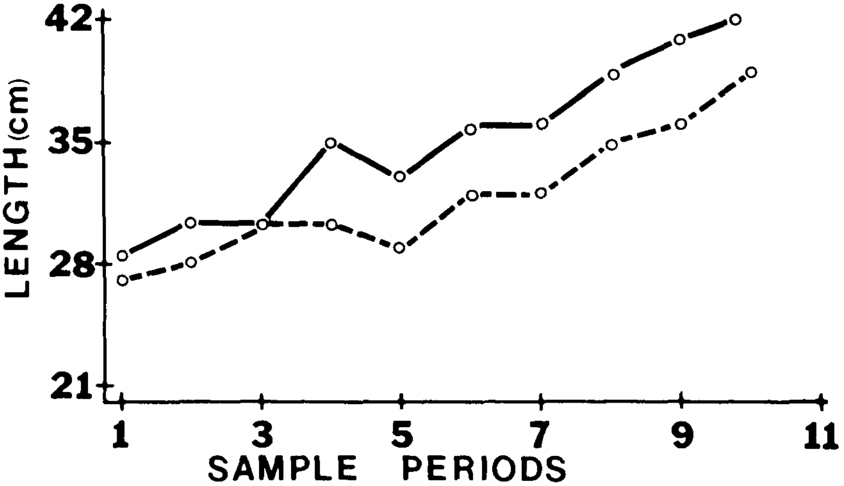

Fig. 8. -Mean biweekly growth rate of experimental (solid line) and control (broken line) fish.

wind; and cloudy skies. Biweekly sampling of oxygen is by no means a way of informing one of potential depletions. A daily pre-dawn program of recording oxygen concentrations would have to be initiated with hourly recording during the period between 0000 and 0600 hours to monitor this potential problem sufficiently. However, had suficient aeration equipment been available, it is possible that the observed loss of fish could have been avoided or minimized.

Stocking density of 3720 fish per ha is currently utilized at the Arkansas State University Fish Farm. Swingle (1959) indicated a decreased mean size of harvested catfish at and above stocking densities of 5000 fish per ha, therfore, one might perdict that

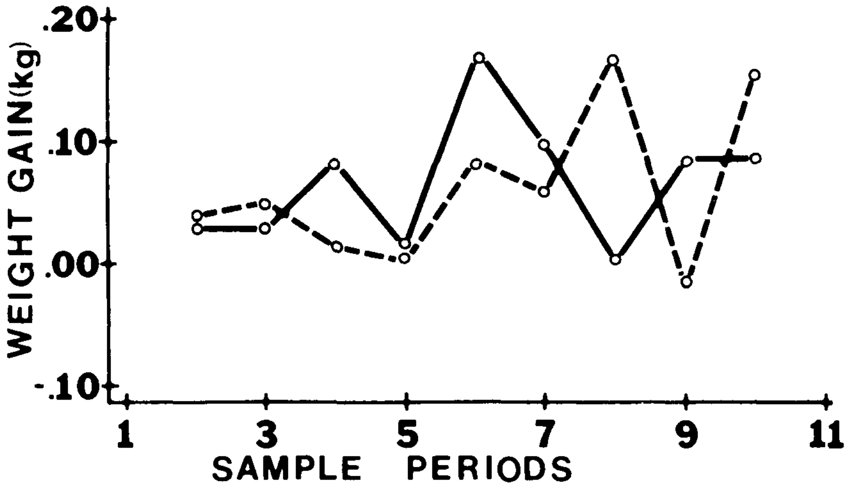

Fig. 9. -Mean biweekly weight gain of experimental (solid line) and control (broken line) fish.

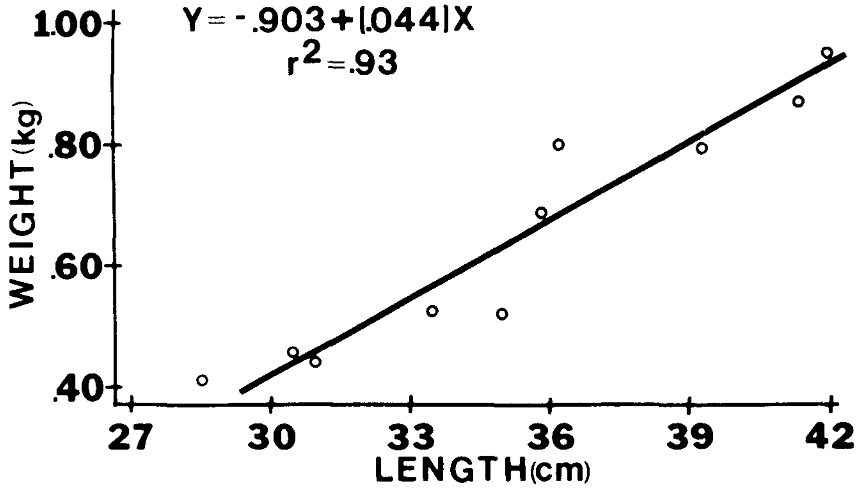

Fig. 10. -Regression of mean weight on the mean length of experimental fish.

cropping would not be beneficial at the stocking rate used in this study. Cropping fish as they exceeded .681 kg insures that growth did not include gonad development (U.S. Bureau of Sport Fisheries and Wildlife 1973).

Results of this study indicated cropping populations with these initial stocking densities and under the stated conditions did not produce significant gains in weight or growth rate during the study period.

Although experimental fish had an elevated growth curve in weight and length in comparison with control fish, the rates were parallel (Figs. 7 and 8). Therefore, with the exception of initial size differences, the rates of growth in the experimental and control fish were the same (Tables 3-6). Length-weight relationships of channel catfish have long

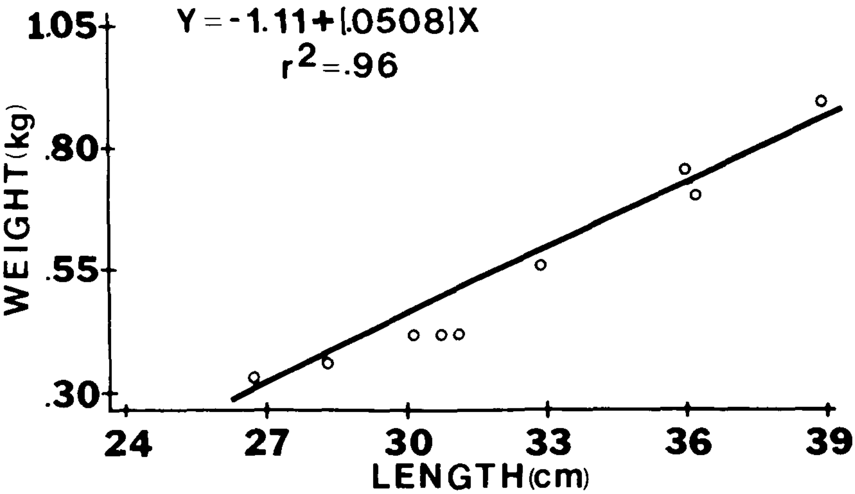

Fig. 11. -Regression of mean weight on the mean length of control fish.

been established (Swingle 1958). With a .963 correlation betwen mean length and weight in the experimental fish and a .982 correlation in the control, either was considered a good indicator of growth when compared to weight gain.

Periodic gains in weight of the experimental fish were followed in 4 weeks by comparable weight gains in the control fish (Fig. 9). For example, the peaks in control populations on the 6th and 8th sampling periods corresponded to peaks in exerimental populations on the 4th and 6th sampling periods, respectively. The lag was due to the initially smaller size of the control fish (Tables 3-6). However, during the last 4 week period the experimental fish did not show this trend (Fig. 9). This was attributed to the observation that the growth rate increases up to a body weight of about .91 kg, after which the rate slows because of gonad development (U.S. Burear of Sport Fisheries and Wildlife 1973).

Results of the F-test and t-test revealed no significant differences in weight gains or mean gain ($P \geq 0.05$) between the experimental and control fish; therefore, cropping had no effect upon growth rate or weight gain. the stocking density utilized in this study was apparently less than, or possibly equal to, the maximum density that would allow optimal growth with no limiting spatial factor. It is logical to reason that, if the stocking density exceeded the maximum level, cropping, by reducing density, would have resulted in greater growth rates in experimental populations. The stocking density in this study would appear to be approaching maximum levels allowed without cropping (Swingle 1958).

Selective removal of channel catfish stocked at 3720 fish per ha can be beneficial as well as detrimental. If precautions are taken not to stress the fish (e.g. prevent rough handling, work fish near water inlet with aeration, seine early morning before water becomes too hot, and work quickly and efficiently to prevent long pen-up time) cropping can be advantageously utilized to remove those fish that are "faster growers." This allows one to sell a uniform marketable fish during the season.

However, since the fish in this study grew at maximum rate and weight gain, no periodic removal of fish was necessary. Because numerous partial harvests could become expensive from strictly a labor standpoint, one could seine at the end of the growing season and still harvest a uniform marketable fish when stocked at an initial density of 3720 fish per ha.

LITERATURE CITED

Allen, K.O. 1974. Raceway production: four costs that can make or break you. Fish Farming Industries. 5(3):23-25.

American Public Health Association. 1974. Standard methods for examination of water and waste water. 14th ed., New York.

Lee, J.S. 1973. Commercial catfish farming. the Interstate Printers and Publishing, Inc. Danville, Illinois.

Lewis, W.M., and R.J. Sheehan. 1976. Channel catfish culture: state of art 1976. Proc. Annu. Conf. Southeast. Assoc. Fish Wildlife Agencies. 30:234-238.

Lovell, R.T., R.O. Smitherman and E.W. Shell. 1978. Progress and prospects of fish farming. pp. 262-290. In Altschul, Aaron M., new protein foods. Academic Press Inc. New York.

Runyon, R.P., and A. Haber. 1977. Fundamentals of behavioral statistics. 3rd ed. Addison-Wesley Publ. Co. Reading, Massachusetts.

Ryan, T.A., B.L. Joiner, and B.F. Ryan. 1976. Minitab student handbook. Duxbury Press. North Suituate, Massachusetts.

Snow, J.R. 1976. Increasing the yield of channel catfish rearing ponds by periodic division of the stock. proc. Annu. Conf. Southeast. Assoc. Fish Wildlife Agencies. 30:230-245.

Swingle, H.S. 1958. Experiments on growing fingerling channel catfish to marketable size in ponds. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 12:63-72.

Thornbury, W.D. 1965. Regional geomorphology of the United States. John Wiley and Sons, Inc. New York.

U.S. Bureau of Sport Fisheries and Wildlife. 1973. Second report to the fish farmers. Resource Publ. 113, U.S. Fish and Wildlife Service Washington, D.C.

Welch, P.S. 1948. Limnological methods. McGraw-Hill Book Co. New York.