STOCKING DENSITY: ITS EFFECT ON CAGED-CHANNEL CATFISH PRODUCTION

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Abstract: Channel catfish (*Ictalurus punctatus*), were reared in 1.0 m^3 cages suspended in the intake canal of a cooling reservoir. Effects of density were tested by stocking cages in replicates of 4 at densities ranging from 500 to 900 fish in increments of 25 individuals. There was a significant increase in net production and variation in length and a significant decrease in feed efficiency, mean fish weight, and percentage of harvestable-size fish as stocking density increased. Survival was not affected by number of fish per cage.

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Number of channel catfish stocked in cages has been found to influence production and growth (Tilton and Kelley 1970, Joyce 1973, Murrell 1973, Hill 1975). Most results have shown that weight yields increase and growth decreases with increasing stocking density. However, little information is available for stocking densities exceeding 600 channel catfish/m^3.

For cages to be utilized economically as an intensive fish culture system, maximum production efficiency per unit volume will have to be achieved. It was the purpose of this study to determine effects of stocking density on performance of channel catfish reared in cages suspended in the intake canal of Trinidad Lake, a cooling reservoir for a steam-electric generating station.

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MATERIAL AND METHODS

This study was conducted at Trinidad Lake in Henderson County, Texas. The reservoir is owned and operated by the Texas Power and Light Company as a source of condenser cooling water for the 400 MW Trinidad Steam Electric Generating Station. Trinidad Lake began filling in 1925 and has a holding capacity of 9.4 X 10^6 m^3, an area of 305 ha, and an averge depth of 3.1 m. Depth of the intake canal, where fish culture operations were conducted, was 6.9 m at the upstream end and gradually decreased downstream to 6.2 m. The lake receives little runoff, but is maintained near constant level by pumping water from the Trinity River.

Sixty-eight rectangular cages, each 1.0 m^3, were used for this study. Cage material and design are described by Kelley (1973). The floating cages were arranged in 4 rows positioned parallel to water flow, 650 m upstream from the power station intake structure. Two main ropes, 9.5 m apart, were secured into position from 4 anchor posts and held 2 rows of cages each. Distance between cages on each row was 1.5 m and distance between cages on each row was 1.5 m and distance between cages on adjacent rows was 0.3 m (Fig. 1).

Cages were stocked from 22 June to 2 July 1974 at 17 densities with channel catfish fingerlings averaging 82.3 g each. Cages on rows 1 and 3 were positioned so that cages at the upstream end (1 and 101) had a density of 900 fish with density decreasing in 25 fish increments to 500 fish in cages at the downstream end (17 and 117). Cages on rows 2 and 4 were arranged in reverse order so that densities at the upstream end began with 500 fish (cages 51 and 151) and increased in 25 fish increments to 900 fish (cages 67 and 167). Cages were designated as upper, lower, outside, or inside depending upon their position in relation to other cages.

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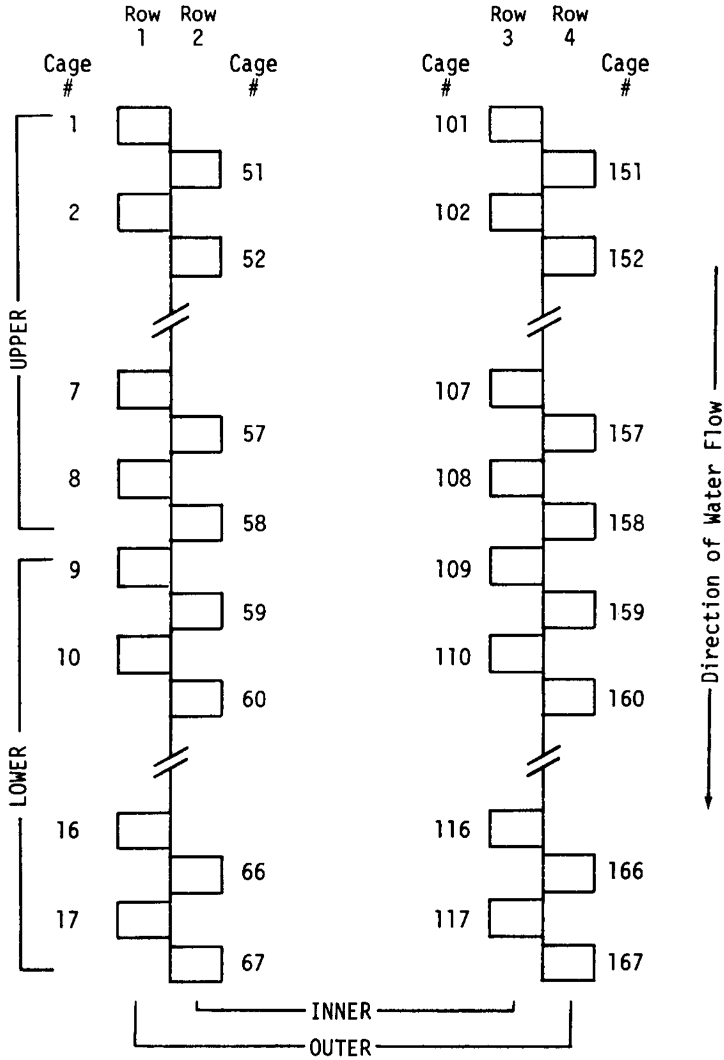

Fig. 1. Four rows of cages suspended in the intake canal of Trinidad Lake showing positions of upper, lower, inner, and outer.

Fish were fed each morning except during inclement weather or unusual working conditions. Amount of food fed was adjusted at weekly intervals and based upon expected weight gains assuming a food conversion ratio of 1.25. Feeding rates were gradually reduced from 3.0 to 2.0 percent of estimated biomass per cage when the daily allotment of food was not completely consumed in half the cages 30 min after feeding. Purina Cage Chow (#5 pellet) was used until fish attained an average weight of approximately 300 g. At that time (17 September), fish were fed a specially designed disc-shaped pellet (Purina Special Mix #5144-3) until experimentation ended. Formulation of the special mix was identical to that of the #5 pellet. After a 112 day culture period, fish were measured individually and weighed according to 25 mm length groups.

Specific physical and chemical features of surface and bottom water above and below the culture area were assayed every 14 days. These included dissolved oxygen, pH, conductivity, total hardness, alkalinity, orthophosphate, ammonia nitrogen, and organic nitrogen. Maximum and minimum water temperatures, from a depth of 1.0 m, were measured daily at the fish culture site.

Production data were analyzed by multiple covariance analysis described by Steel and Torrie (1960). Significance is expressed at the 0.05 level.

RESULTS AND DISCUSSION

It seems logical that increasing numbers of channel catfish per unit volume would increase total production proportionately until the carrying capacity of that volume is reached. The carrying capacity of 1.0 m^3 cages was not determined but results of this study indicate that an increase in stocking density up to approximately 800 fish m^3 resulted in a significant increase in net production (Fig. 2). This was, however, paralleled by a significant decrease in mean weight per fish. In similar studies with caged channel catfish, Beasley (1971), Joyce (1973), Murrell (1973), and Hill (1975) found that increased stocking density affected growth in a similar manner.

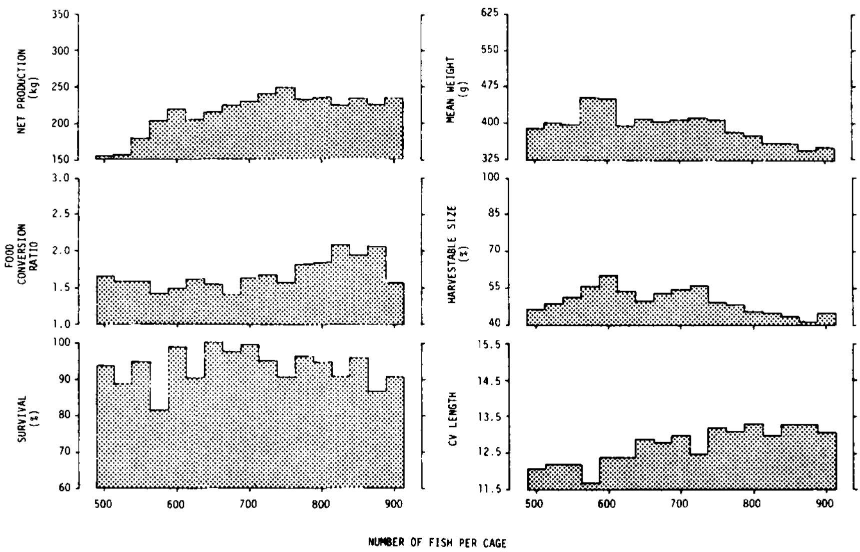

Fig. 2. Effects of stocking density on net production, food conversion ratio, percentage survival, fish mean weight, percentage harvestable-size, and coefficient of variation in length for channel catfish cultured in cages in the intake canal of Trinidad Lake for 112 days.

The tendency toward decrease in weight per fish associated with increasing stocking rates may be because of decreasing water quality in cages or to some minimal space requirement of channel catfish that must be met for normal growth. Studies by Andrews et al. (1971) and Allen (1974) have shown that faster water exchanges through tanks increased growth response of channel catfish stocked at higher densities. Application of their findings to this study implies that metabolic waste from cages stocked at higher densities may not be removed at rates comparable to cages stocked at lower densities.

Increasing stocking densities also decreased efficiency of food conversion significantly. The decrease in feed efficiency may be a reflection of overfeeding resulting from overestimation of the standing crop of fish in some cages, since all fish were assumed to have the same food conversion, regardless of stocking density, when estimating weekly weight gains. Also, as fish size increased, feeding activity produced water currents and turbulence great enough to carry food under the feeding ring and some food washed from cages into the reservoir. It was visually estimated that such feed losses amounted to 10 percent in some cages. The larger pellet fed to fish during the latter part of the culture period appeared to decrease this type of feed loss.

Increased stocking densities were related to significant reduction in percentage of harvestable-size fish (TL > 326 mm) and an increase in size variability (Fig. 2). Cages stocked with 750-900 fish, the highest densities tested, had lowest percentage of harvestable-size fish and greatest variability in size. Although this study did not identify the factors causing the increased size varation associated with the higher densities, it does suggest that 750 fish/m^3 may represent the density-tolerance threshhold for caged channel catfish.

Several studies (Andrews et al. 1971, Stickney et al. 1972, Joyce 1973, Murrell 1973, Allen 1974) have shown that survival of channel catfish decreased as stocking levels inccreased. In this study, density of fish did not affect survival.

Cage location had a significant effect on food conversion and size variability of the caged fish (Table 1). Best growth was observed in cages of fish cultured at lower and inner positions. Poor performance of fish at upper positions is thought to have been caused by slowed removal of fish metabolic wastes from cages. Eddy currents created by a skimmer wall 5 m upstream from the fish culture site recirculated water in the upper cage area. Perhaps cages of fish at lower positions were inadvertently allowed more opportunities to feed since it is likely that some feed washing from upper cages flowed through cages of fish downstream. Friction of cages no doubt reduced water current enough so that fish on inner rows expended reasonably less energy for position maintenance than fish on outer rows. Also, wave action and boating activity may have caused increased fish activity in cages at outer positions. Murrell (1973) reported better growth of channel catfish located on inner rows when cages were arranged in a manner similar to those of this study.

Table 1. Production data means for channel catfish reared at Trinidad Lake, Texas, during 1974 in suspended cages located at upper-outer, upper-inner, lower-outer, and lower-inner positions.

	Cage Location			
Production Parameter	*Upper-Outer*	*Upper-Inner*	*Lower-Outer*	*Lower-Inner*
Net Production (kg)	165.39	199.23	207.18	210.78
Food Conversion Ratio	2.57	1.86	1.84	1.78
Survival (%)	88.6	94.2	93.2	94.6
Mean Weight/Fish (g)	374	383	403	400
Harvestable-Size (%)	47.9	44.5	53.8	51.5
CV Length (%)	12.9	12.8	12.3	12.9

The quality of water at Trinidad Lake was generally sufficient for fish culture during this study (Table 2). However, water temperature surpassed 35 C for 8 days during the latter portion of July. On those days, feeding activity of caged-channel catfish was markedly reduced.

No single optimum stocking density of channel catfish in 1.0 m^3 cages was determined in this study. It appears that best stocking rate will be a compromise which takes into consideration various growth factors. If the primary objective is to obtain maximum weight of small fish, a stocking rate of 800 or more fish/m^3 may be most desirable. When production economics of maximum marketable fish/unit volume is considered, then densities between 600-700 fish/m^3 appear to be the most efficient. This study indicates that stocking rates of 600-750 fish/m^3 yield total weights almost as high as obtained at the higher densities and revenue received for the additional weight of fish obtained at higher densities would not be sufficient to recover capital outlay for fingerlings and feed. The most efficient method of space utilization would be to stock at a high rate and reduce the population in cages by partially cropping as fish increased in size. Snow (1978) outlined the benefits of stocking channel catfish into ponds at densities to give optimum number and weight for edible-size fish. He reports that periodic splitting of the stock shows promise of increasing gain/meal day. Similar benefits should be possible with caged channel catfish.

Table 2. Ranges and means[a] of water quality characteristics measured in Trinidad Lake, Texas, when caged channel catfish were being reared during 1974.

Water quality characteristic	*Range*	*Mean*
Temperature (C)	19.4 - 37.2	28.0
Dissolved Oxygen (mg/l)	5.4 - 9.2	7.9
pH	9.1 - 9.3	9.2
Conductivity (μmhos/cm)	960 -1,019	983
Total Hardness (mg/l)	140 - 164	148
Total Alkalinity (mg/l)	164 - 218	188
Orthophosphate (mg/l)	0.26- 1.50	0.82
Ammonia Nitrogen (mg/l)	0.0 - 0.39	0.09
Organic Nitrogen (mg/l)	2.06- 3.87	2.59

[a]Figures are the average of surface and bottom measurements taken above and below the fish culture site.

LITERATURE CITED

Allen, K. O. 1974. Effects of stocking density and water exchange rate on growth of channel catfish, *Ictalurus punctatus* (Rafinesque), in circular tanks. Aquacult. 4:29-39.

Andrews, J. W., L. H. Knight, J. W. Page, Y. Matsuda, and E. E. Brown. 1971. Interactions of stocking density and water turnover on growth and food conversion of channel catfish reared in intensively stocked tanks. Prog. Fish-Cult. 33:197-203.

Beasely, P., Jr. 1971. Cage culture of channel catfish stocked at different densities. M.S. Thesis. Memphis State Univ., Tennessee. 32 pp.

Hill, T. K. 1975. Comparisons of albino and normal channel catfish grown in cages in a pond. Proc. Annual Conf. Southeastern Assoc. Game Fish Comm. 28:231-235.

Joyce, J. A. 1973. The effects of stocking density and feeding rate on the growth of channel catfish, *Ictalurus punctatus* Rafinesque, in floating cages. M.S. Thesis. Texas A&M UUniv., College Station. 117 pp.

Kelley, J. R., Jr. 1973. An improved cage design for use in culturing channel catfish. Prog. Fish-Cult. 35:167-169.

Murrell, J. L., Jr. 1973. The intensive cage culture of channel catfish, *Ictalurus punctatus* (Rafinesque), in the intake and discharge canals of a steam electric generating station. Trinidad, Texas. M.S. Thesis. Texas A&M Univ., College Station. 141 pp.

Snow, J. R. 1978. Increasing the yield of channel catfish rearing ponds by periodic division of the stock. Proc. Annual Conf. Southeastern Assoc. Game Fish Comm. 30:239-245.

Steel, R. G. D., and J. H. Torrie. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill, New York, N.Y. 481 pp.

Stickney, R. R., T. Murai, and G. O. Gibbons. 1972. Rearing channel catfish fingerlings under intensive culture conditions. Prog. Fish-Cult. 34:100-102.

Tilton, J. E., and J. E. Kelley. 1970. Experimental cage culture of channel catfish in heated discharge water. Proc. 1st Annual Workshop World Maricult. Soc. 1:73-87.