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Abstract

Largemouth bass Micropterus salmoides, Lac. fingerlings were successfully grown in cylindrical cages made of a synthetic netting fabric. Diet was Oregon Moist Pellet or floating trout pellets fed ad lib. Feed conversions ranged from 1.31 to 5.19 for 16 cage replications included in four trials. One trial was in the fall months when water temperature averaged 14.7°C. Another was during the fall and winter (144 days) when average water temperature was 12.8°C. The other two were done in the summer at an average water temperature of about 27°C. Survival was 83.7 percent or higher for all lots except two where side effects from a disease treatment caused mortality. Response of the test animals to the cage environment was comparable with what had been observed in rearing this size bass on artificial feed in small earthen ponds. Cage design was satisfactory and the method shows promise for specialized use in bass culture.

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Introduction

Growth of fishes in cages has attracted widespread attention in parts of the United States in recent years Schmittou, (1970), Lewis, (1969), Collins, (1971). In contrast, cage culture (basket culture) has been used in Asia for many years according to Thiemmedh, (1961).

Asian work has included a variety of species while cage culture in the United States has dealt mainly with the catfishes, blue, channel and white. However, Pagan ,(1972), reported successful culture of Tilapia aurea in cages. Also, Collins (1972), was able to rear rainbow trout, Salmo gairdneri, Rich. by this method. Powell (1973) grew striped bass Morone saxatilis, Walbaum, in cages suspended in brackish water.

Adaptability of several species to cage confinement prompted a study to test suitability of the cage for holding largemouth bass, Micropterus salmoides, Lac. during growth periods. Work at the Marion National Fish Hatchery had developed production methods for rearing largemouth bass in earthen ponds on a diet of artificial food which gave predictable results (Snow, 1968). Thus, a technique of training bass fingerlings to live and grow under confined conditions was well established and considerable data were available for comparison with growth and survival rates obtained in cages. An opportunity developed in the fall of 1971 to conduct a trial when water temperature was cool. Two additional trials were carried out during the summer of 1972 with a final cool season trial in the fall and winter of 1972-73.

Material and Methods

Cage design has varied depending upon the ideas of the fish culturist. Although the cages we had seen were rectangular, it was thought that an active fish such as the largemouth bass could be held to a better advantage

in a cylindrical container. Our experience in handling the largemouth bass indicated that the species was susceptible to skin damage which often resulted in columnaris and other bacterial infections. To minimize this and other effects of crowding, a cylindrical container was designed having a capacity of about one cubic meter. To further decrease the possibility of skin abrasion and to insure durability, a plastic screen material known commercially as Vexar was used. Two mesh sizes were tried, one of 0.64 cm, the other about 1.27 cm. The cylinders were held in shape by rings made of 1.27 cm wide strap methal welded into circles 117 cm in diameter which were located at the top and bottom of the cylinder. A feed retaining ring or cylinder of plastic netting 54 cm in diameter, extending into the water about 25 cm, aided in keeping the feed inside the cage until it could be eaten. Cages were supported 14-18 cm off the pond bottom in water about 85 cm deep by means of three steel fence posts driven into the pond bottom. Figure 1 shows cages of both mesh sizes. Figure 2 depicts details of fish harvest. Volume of water in the cage was approximately 0.67 m^3 when the 0.32 ha. pond was full. Water level fluctuation ranged from 0-15 cm.

Four trials were conducted in the feasibility study. Trial 1 took place in the fall of 1971 using three cages of 1.27 cm mesh fabric. Cages were stocked with about 300 fish each on October 18. The test animals had been reared to a size of about 11.5 cm total length (weight about 15 g) in earthen rearing ponds. They were slower growing individuals which had been graded from lots shipped as 18 cm size. Prior to being placed in the cages, they had been held in a concrete tank of about 1.41 m^3 volume and hand-fed for two weeks. Number and weight of fish stocked is shown in Table 1. The fish were fed floating trout pellets ad lib, each day. The first week two feedings were given per day. After that they were fed once each day. Trial

1 began on October 18 and continued until December 18. At the end of the period, fish in each cage were counted and weighed. Water temperatures were obtained from a thermograph located in a similar nearby pond less than 100 meters away.

Because of the smaller size fish available, a mesh size of 0.64 cm was used for three cages in Trial 2. Fingerlings were trained to feed on Oregon Moist Pellet (OMP) in concrete holding tanks following a technique described by Snow (1965). Two cages were stocked on June 9 and the third was stocked and feeding begun on June 16. The latter cage was stocked with fingerlings from a different lot which were somewhat larger than those used in the first two cages. Stocking rate was 1,500 fish per cage and the volume of water again approximated two-thirds of a cubic meter. Food in this trial was OMP supplied ad lib. four times per day, seven days per week. The trial covered a period of 41 days for two cages and 34 days for the third. A secondary objective of the work was to grow the test animals to a size large enough to enable them to be held in 1.27 cm mesh cages. Stocking data are shown in Table 2. Water temperatures during this period were taken in an adjoining pond at a depth of 150 cm and averaged 27.2°C.

The trial was terminated on July 20. After removal to holding tanks, the fish were counted, weighed and sorted into three size groups, small, medium and large.

Trial 3 was initiated the day following termination of Trial 2 using the medium and large size fingerlings produced in that trial. Three cages made of 1.27 cm fabric were stocked with fingerlings of an average size of 28 gms. It was necessary to supplement this size with 1.59 kg (105 fish) of a 15 g size. Numerical stocking rate was 500 fish per cage containing a water volume of about two-thirds m^3. Three cages made of 0.64 cm mesh

fabric were stocked with 600 15 g fish. Prior to stocking, the fish were given a 12-hour prolonged treatment of penicillin-dihydrostreptomycin at a rate of 12 ppm. After stocking, they were fed 1/4-inch OMP medicated with oxytetracycline at a level to provide 3.5 grams of antibiotic activity per 45.5 kg of fish per day. Feeding medicated OMP was discontinued after the seventh day and the diet was changed to a floating trout pellet[4]. Frequency of feeding during Trial 3 was three times daily. Dead fish were removed from the cages as they were noted and algae was scrubbed from the fabric once or twice weekly when growth made this practice necessary. All cages were located in one pond of about 0.32 ha area.

Trial 3 covered a period of 66 days from July 21 through September 25. Bottom water temperatures from an adjoining pond were available and a record of water temperature in the cage area was taken for one month using a Ryan submersible recording thermometer for comparison with the thermograph.

Trial 4 was begun on October 6, 1972. Four of the 1.27 cm mesh cages were moved to another pond 0.10 ha in size and stocked at two rates. Two cages received 5.89 kg (13 pounds) of bass of an average weight of 44.4 g and two others were stocked with twice that weight. Feeding with medicated OMP ad lib was done two times daily for seven days. The ration was then changed to floating trout feed[4]. Twice daily feedings were given until November 1 after which the fish were fed once a day when water temperature was high enough for food to be consumed. The amount of feed provided to each cage was weighed and a record was kept of fish mortality. Water temperature was taken with a Ryan submersible thermograph suspended at a depth of 75 cm.

The trial was to last through the winter and terminate in early spring.

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[4] Purina #6 floating trout chow.

At the conclusion of the study the test animals were individually weighed and measured to provide an inventory of the survivors and data on growth.

Results and Discussion

The results of Trial 1 are shown in Table 1. Survival of test animals was excellent. Weight gains were in line with the prevailing water temperature which averaged 14.7°C. for the period. Feed conversion was somewhat higher in Cage 3 than anticipated for unknown reasons. Cages 1 and 2 showed feed conversions which were comparable to those obtained for pond feeding during the cool season of the year. No unusual problems were encountered and the outcome indicated a need to repeat the work under conditions where water temperature was conducive to more rapid growth.

Since the test fish available for Trial 2 (Table 2) were smaller, the number per cage was increased to 1,500. Cages 2 and 3 were stocked with slightly smaller fish than Cage 1 but a one week delay in stocking Cage 1 probably reduced the size differences. Performance of the two lots of fish was distinctly different and indicate the desirability of using test animals from a common lot when comparisons are being made. Since this trial was mainly a feasibility study the disparity in response was not considered to be harmful to the outcome. As in Trial 1 the results were highly encouraging. Survival was high. Growth rate was slightly lower than we have obtained in ponds on an OMP diet but was still quite acceptable.

The poorer performance of the fish in Cage 1 could have been altogether due to the difference in response of the two lots to the care given. However, the lower survival percentage in Cage 1 may relate to the recovery of 88 bass fingerlings from the open pond when it was drained following the termination of Trial 3. These fish were observed around the cages on several occasions during the study although the first time they made their appearance is unknown.

No opening large enough for escape of the contained fish was found in Cage 1, but there were no dead fish noted in the cage and cannibalism as indicated by unusually large individuals was not evidenced. The lower survival percentage and higher food conversion suggest abnormal circumstances in this unit. Recovery of more fish than was stocked in Cage 2 is an indication of occasional fallibility of the fish culturist depending upon number-weight relationship to provide an accurate estimate of numbers. A possible explanation is given as a footnote of the table. Fish in Cages 2 and 3 showed excellent food conversion and rate of growth. The numerical rate of stocking used appears to be about right for an acceptable rate of growth although it would have been necessary to reduce the fish density if continued growth at an optimum rate was to be maintained. A density of 1,668 fish per cage showed more than 25 percent of the number of the small size group while one of 1,394 had 11 percent in this category. Further evidence of the disparity between Cages 2 and 3 and Cage 1 is the fact that 28 percent of the fish in Cage 1 were in the small size group. There were no unusual problems in Trial 2. The fish fed well and oxygen was not a problem.

In Trial 3 six cages were involved, three 0.64 cm mesh and three of 1.27 cm mesh fabric. Fish from Trial 2 weremixed and used in Trial 3. Kilograms stocked per cage ranged from 9.07 for the fine mesh to 14.29 for the coarse mesh. It was necessary to add 1.59 kg of the medium size fingerlings in Cage 5 to bring the number up to specification. Feeding medicated feed and giving overnight prophylaxis was effective in holding observed mortality to a low level. Disease developed in three cages during the last week of the trial and probably would have required treatment if the trial had not been scheduled for termination. This suggests that the 70-day feeding

period was about as long as the observed density could be maintained under our conditions without developing a disease epizootic.

Best gain was measured in Cages 2 (23.68 kg.) and 6 (24.59 kg.) stocked with the larger size fingerlings. The other four cages gained at about the smae rate, from 18.19 to 20.28 kg. Conversion was lower in the slower gaining cages in three instances ranging from 1.32 to 1.46 as compared to 1.50 and 1.58 in the two higher gain lots. Cage 5 showed a conversion of 2.07 which was different enough from the other five to suggest that fish in this unit were not a part of the same population as the other cages. Bottom water temperature during the trial averaged 27.3°C. A month's continuous temperature record taken with a Ryan submersible recording thermometer suspended near the edges at a depth of 75 cm showed a mean temperature two degrees higher than the bottom measurements.

Considering the size achieved in Trials 2 and 3, growth in the cages was comparable to that measured in small earthen ponds stocked at a rate of about 50,000 fish per ha. Average length was about 18 cm attained in a growing period about 110 days. Details of Trial 3 are shown in Table 3.

The fish size attained in Trial 3 was determined by measuring a sample of each lot in five instances and the entire lot in Cage 5. Length was taken to the nearest millimeter and weight to the nearest tenth of a gram. Sample size varied from 200 to 260 fish per cage. Fish not measured and weighed individually were counted and weighed as a lot. Length-weight relationships for Cage 5 are shown in Figure 3.

Results in Trial 4 did not parallel those in Trial 1. Light mortality was noted in all cages following stocking. This soon ceased and the fish fed well until mid-December. They then stopped feeding and light mortality was noted December 12-20. Examination, indicated the trouble to be columnaris

disease coupled with a secondary fungus infection. To minimize handling stress it was decided to treat the pond rather than to move the fish. Treatment of choice was 25 ppm formalin and 0.1 ppm malachite green as a pond treatment. After applying the chemicals on December 21, an aerator was installed at the deep end of the pond. The diet of the fish also was changed on that date to oxytetracycline-medicated OMP.

On December 23 the aerator malfunctioned and a substantial mortality was noted in the two cages located nearest the deep end of the pond. Presumably either a "hot" spot developed in this area causing fatal stress to some of the fish in the two deep cages or oxygen became deficient in the area of these cages. Because of the water temperature the former supposition is more logical. One cage sustained a loss of 45 fish while the second had 27 dead.

Loss in the other two cages, located about 100 feet away in shallower water, was negligible. Food intake improved by the second day following treatment and the fish were completely recovered in about 14 days. Basic cause of the infection was attributed to rough edges of the plastic fabric on the feeding funnel. In the process of consuming the floating pellets the competing fish abraded head and caudal peduncle areas which subsequently became infected. The cage was modified to eliminate the abrasive surface and no further trouble was experienced.

The trial was continued until February 27. Two days following termination of feeding, individual weights to the nearest gram and total lengths to the nearest 0.1 cm were taken. Based on these and earlier measurements, data in Table 4 are presented to illustrate results of Trial 4.

Average water temperature at the 75 cm depth was 12.8°C. Ice covered the pond surface on two occasions for short periods. During one period in

January no food was taken for five days. Later, in early February, a four-day interval occurred when no feed was taken. When warmer temperatures followed these cold spells feeding activity was vigorous. These observations supplement a previous report (Snow, 1969) that little artificial food is consumed by largemouth bass of this size when water temperature drops below 8.0°C (45°F).

While the results of Trial 4 were not as successful as those earlier the outcome was greatly affected by the quality of the husbandry given. Disregarding the mortality caused by the disease treatment would have made survival and feed conversion comparable to the other trials. It was demonstrated that measurable growth can be made by bass in cages during cool season months at this latitude when fed artificial feed. Whether the gain obtained from attempting to feed during the cold periods is sufficient to pay for the time involved in feeding is doubtful. In a situation where the gain is quite valuable, feeding on alternate days with no feeding when temperature is below 8°C. seems advisable.

The heavier stocking rate used seemed about right for winter conditions. The lower rate did not appear to make best use of cage space. Results suggest that up to 23 kg of fish per 0.67 m^3 is acceptable and does not reduce the growth rate.

Results of these trials indicate that the cage environment is suitable for rearing largemouth bass to a size of 15-20 cm (6-8 inches). As with other species, emphasis on quality of the ration and disease control are essential if consistent returns are to be obtained. Feed conversion may be slightly higher in cages than in ponds, probably reflecting in part the contribution insects make in the pond environment.

Although the optimum stocking density was not established by this work, it appears that a final fish weight of 40-55 kg per cubic meter in a 1.27 cm mesh fabric cage can readily be achieved. Back calculation from this weight to include length of growing period, size of fish available for stocking and prevailing water temperatures should enable the fish culturist to estimate the beginning stocking density. For a complete growing season (110-120 days) a starting weigh of 5-12 kg per 0.67 m^3 of water volume appears about right for our conditions. If growth slows down, a marked disparity of size develops or disease losses occur, reducing the density by [illegible]ing and recombining size groups can be resorted to as a means of correcting the difficulty.

Circumstantial evidence suggests that feeding oxytetracycline at a level of 3.5 g antibiotic activity per 45.4 kg of live fish weight for seven days before and after handling the fish reduced losses caused by skin infection.

Because of the limited scope of this work and the small number of replications, caution should be exercised in applying the results of our study without feasibility trials under the conditions where the application is to be made.

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Table 1. Stocking and recovery data from Trial 1.

Item	Cage 1	Cage 2	Cage 3
Date stocked	10-18-71[a]	10-18-71	10-18-71
Date removed	12-18-71	12-18-71	12-18-71
Number stocked	404	328	302
Number removed	402	320	300
Percent survival	99.5	97.6	99.3
Weight stocked (kg)	6.14	5.44	4.54
Weight harvested (kg)	10.91	10.43	8.16
Gain in weight (kg)	4.77	4.99	3.62
Feed supplied (kg)	7.89	7.89	8.71
Feed conversion	1.65	1.58	2.41

[a]300 fish weighing 5.00 kg were stocked on this date.

104 additional fish weighing 1.13 kg were stocked on 11-10-71.

Table 2. Stocking and recovery data from Trial 2.

Item	Cage 1	Cage 2	Cage 3
Date stocked	6-16	6-9	6-9
Date harvested	7-20	7-20	7-20
Days fed	34	41	41
Number stocked[a]	1,500	unknown	1,500
Number removed	1,268	1,668	1,394
Survival, percent	84.5	unknown	92.9
Weight stocked, kg	6.80	4.54[a]	4.54
Weight removed, kg	22.45	28.57	27.90
Gain, kg	15.65	24.03	23.36
Feed supplied, kg	30.89	35.02	35.74
Feed conversion	1.97	1.46	1.53
Size groups, No. and Wt.			
Small	350-3.18 kg	425-3.86 kg	150-1.36 kg
Medium	510-11.98 kg	795-12.02 kg	660-9.98 kg
Large	408-11.57 kg	448-12.7 kg	584-16.56 kg

[a]Recovery data from Cage 2 suggests that an error of .907 kg occurred in weighing out fish for stocking. Probably the actual number stocked was nearer 1,800 than 1,500. This would give a survival of 93 percent and a feed conversion of 1.51 which is almost identical with results in Cage 3 where fish from the same lot were stocked.

Table 3. Stocking and recovery data for Trial 3.

Item	Cage Number 1	3	4	2	5	6
Date stocked	7-21	7-21	7-21	7-21	7-21	7-21
Date harvested	10-2	10-2	10-2	9-25	9-25	9-25
Days fed	72	72	72	65	65	65
Number stocked	600	600	600	unknown	500	unknown
Number removed	591	532	561	524	437	554
Survival percent	98.5	88.7	93.5	unknown	87.4	unknown
Weight stocked, kg	9.07	9.07	9.07	14.29	12.93	14.29
Weight removed, kg	29.35	27.94	27.26	37.97	31.16	38.87
Gain, kg	20.25	18.87	18.19	23.68	18.23	24.58
Feed supplied, kg.	26.67	26.67	26.50	37.42	37.65	36.97
Conversion	1.32	1.41	1.46	1.58	2.07	1.50

Table 4. Stocking and recovery data from Trial 4.

Item	Cage 1	Cage 2	Cage 3	Cage 4
Date stocked	10-6-72	10-6-72	10-6-72	10-6-72
Date harvested	2-27-73	2-27-73	2-27-73	2-27-73
Days fed	144	144	144	144
Number stocked	136	294	148	283
Number removed	83	213	124	255
Survival, percent	61.0	72.4	83.8	90.1
Weight stocked, kg	6.03	11.75	6.03	11.75
Weight removed, kg	8.23	19.20	11.82	20.91
Gain, kg	2.20	7.45	5.79	9.16
Feed supplied, kg	11.39	12.47	11.43	12.61
Conversion	5.18	1.67	1.97	1.38
Observed mortality	49	24	16	11
Average length in cm	18.57	18.29	18.70	18.11
Average weight, gm	99.1	90.0	95.2	82.0
Maximum length attained in cm	21.2	22.8	22.3	22.6
Minimum length in cm	16.1	15.0	14.5	15.4

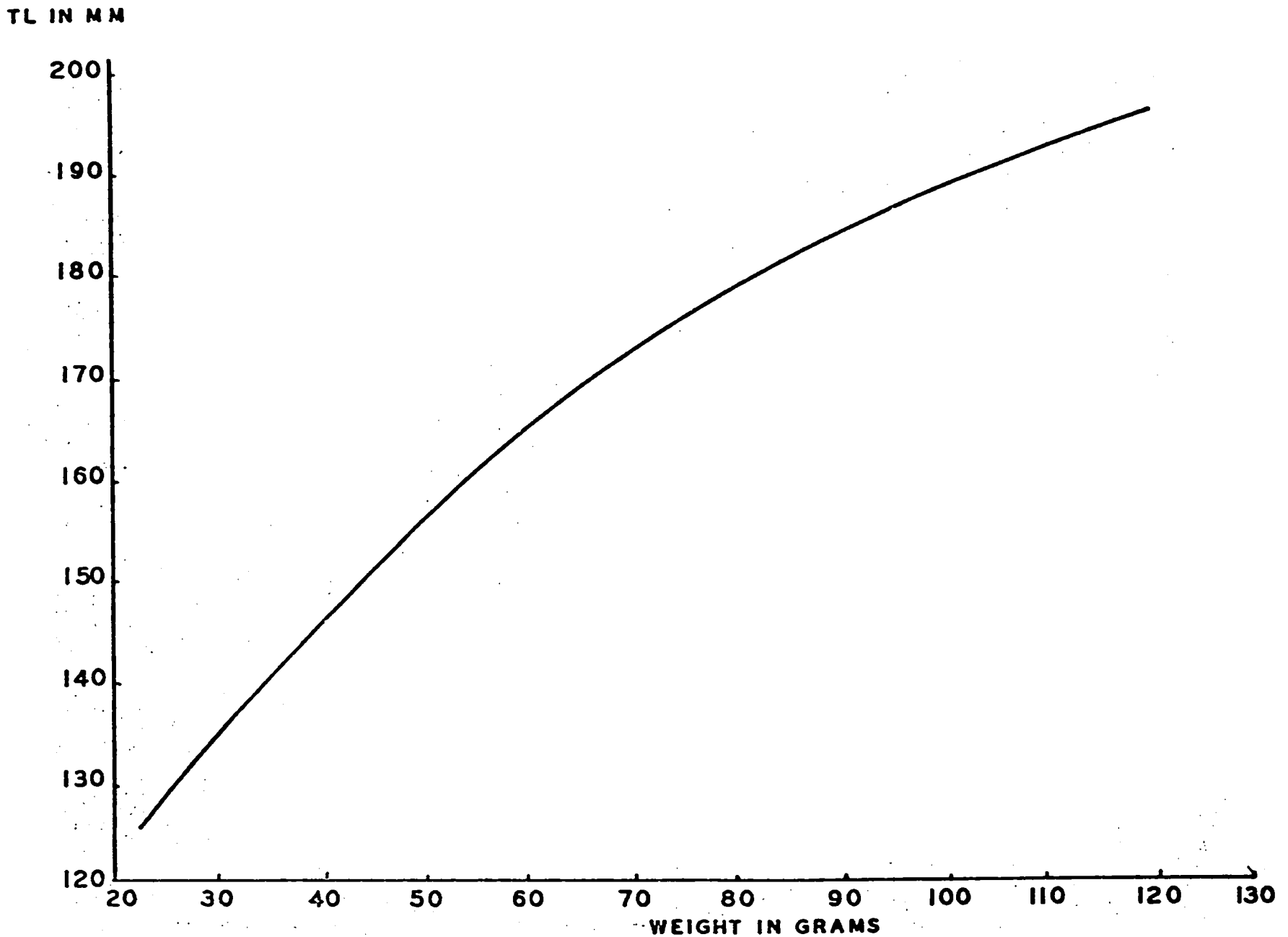

FIGURE 3. LENGTH-WEIGHT RELATIONSHIPS - 437 FISH FROM CAGE 5.