CAGE AND RACEWAY CULTURE OF STRIPED BASS IN BRACKISH WATER IN ALABAMA[1]

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ABSTRACT

Cage and raceway culture of striped bass, *Morone saxatilis* (Walbaum), in brackish water was conducted at the Marine Resources Laboratory, Dauphin Island, Alabama during the period 1 July 1971 to 2 November 1971. The effects of two feeds and two feeding regimes on the growth, food conversion and survival of fingerlings cultured in ½" mesh cages (1 yd.^{3}) were studied.

Growth, food conversion and percentage survival was better among fish fed the trout chow. The feeding regime of four times daily enhanced growth and survival among fish fed either of the two diets.

Striped bass cultured in a 760-gallon circular raceway increased their weight by 832 percent over a 93 day period. Overall food conversion and percentage survival was 2.0 and 94.1, respectively.

Results of a stocking density experiment involving fish stocked in cages at rates of 100, 200 and 300 per yd.^{3} are discussed.

INTRODUCTION

Alabama's estuarine areas have historically supported populations of striped bass (Swingle and Kelley, 1968). A large sportsfishery existed in many areas within the estuarine system and a limited commercial catch was taken. The fishery declined in the last twenty years and by 1962 reached a level where striped bass were rarely taken by either nets or angling gear.

In 1967, efforts were begun to reestablish a self-sustaining population. The Marine Resources Division subcontracted with Auburn University under P.L. 89-304 to produce advanced striped bass fingerlings and to investigate various methods of intensive culture of fry and fingerlings.

During 1969 the Marine Resources Division began a project to test the feasibility of raising marine fish, including striped bass, in cages. Preliminary results indicated that cage culture of striped bass appeared feasible, and Project AFC-3 was initiated. One primary objective of this project is to rear striped bass fingerlings to a size of 6-10 inches in brackish water in floating cages for release into Mobile Bay and its contributary streams to establish a stock of the species in Alabama estuaries.

The results of brackish water culture of striped bass at the Marine Resources Laboratory during 1970 identified several problem areas and presented recommendations for future studies (Swingle, 1970). The main problems encountered were (a) poor feed conversion (b) too costly food (c) high mortality. With these problems in mind, culture techniques during 1971 involved the utilization of two different feeds and feeding regimes in attempts to decrease

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[1]/ This research was funded in part by the Department of Commerce, National Marine Fisheries Service under PL 89-304, Project AFC-3.

Presented at the Twenty-sixth Annual Conference, Southeastern Association of Game and Fish Commissioners, October 22-25, 1972, Knoxville, Tennessee.

food conversion, cost and mortality. Preliminary studies were also begun during 1972 to determine optimum stocking densities for cage culture of striped bass fingerlings.

MATERIALS AND METHODS

Experimental Cages and Raceway

Swingle (1971) designed a cage suitable for culturing marine species and Swingle and Tatum (1971) improved the design (Figure 1).

The cage is 3 feet in diameter, 4 feet high, and made of ½ by ½-inch mesh vinyl-coated galvanized hardware cloth 48 inches wide. It is braced at top and bottom by fiberglass hoop-net rings 3 feet in diameter. The rings and bottom are held in place, and the cylinder closed by clamping with hog nose rings. Four styrofoam blocks, secured to the cages with tar coated nylon cord are used as floats. The top is made of ¼-inch mesh galvanized hardware cloth. An eight-inch strip of fiberglass window screen around the cage and ¼-inch mesh plastic cloth attached to the top serve as feeding rings. The cage has a capacity of 1 $yd.^3$. During culture the cages were floated in Dauphin Island Bay adjacent to the laboratory and secured to a system of feeding piers located behind a protective seawall (Figure 2).

A pilot study on raceway culture of striped bass was conducted in a 760-gallon circular fiberglass raceway located in the laboratory. The tank was supplied with a continuous flow of bay water adjusted to approximately 20 gallons per minute and a venturi drain in the center allowed the exit of water from the bottom of the tank. The water was oxygenated with compressed air moving through two, 3-foot lengths of micro-pore filter tubing.

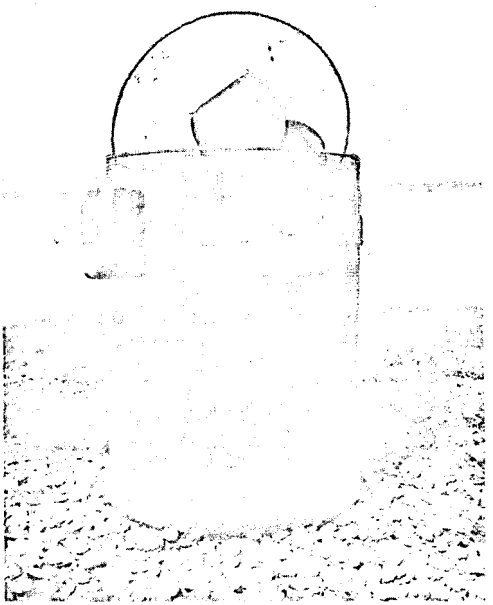

Figure 1. A 0.76 cubic meter (1 yd^3) fish cage with attached flotation device and feeding ring. The cage mesh size is 1.27 cm (0.5 inch) and the material is polyvinyl coated hardware cloth.

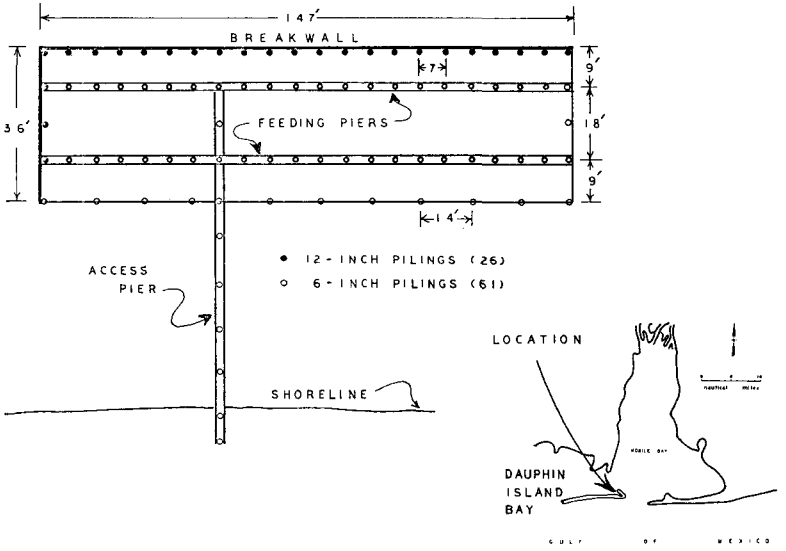

Figure 2. Diagram of feeding piers and seawall constructed in Dauphin Island Bay.

Experimental Fish

On 28 June 1971, 1,500 striped bass fingerling averaging 2.3 grams were obtained from Auburn University to conduct experiments on diets, feeding regime and raceway culture. Due to their small size, they were initially stocked into four ¼-inch mesh cages and fed an experimental ground fish diet and Purina Trout Chow.[2/] Swingle (1970) found that survival among striped bass in cages increased significantly after the fish reached a size of approximately 10 grams. The fish were held in these ¼-inch mesh cages for 18 days. During this period a bacterial infection occurred and 71% of the fish were lost. A diet of medicated Purina Trout Chow consisting of 3 grams active oxytetracycline HCL per 100 pounds of fish per day saved the remainder of the fish and on 4 August 241 fish (12.6 grams/fish) were stocked into the ½-inch mesh cages.

On 3 August, 102 striped bass weighing an average of 9.6 grams each were stocked into the raceway.

Striped bass fingerling for the stocking density experiment were obtained from the Edenton National Fish Hatchery, Edenton, North Carolina during Novembei 1971. These fish were stocked into a ¼-acre brackish water pond and were held in this pond through February 1972. On 29 February the pond was drained and 1,200 striped bass fingerlings averaging 0.30 lbs. were stocked into six ½-inch mesh cages.

All striped bass were of the Cooper River strain.

Experimental Design

In 1971, eight cages stocked at 30 striped bass per cage were used to study the effects of two factors, diet and feeding regime, on the growth, food conversion and survival of the fish (Table 1).

[2/] The use of trade names does not constitute endorsement.

Table 1. Experimental design used to study the effects of diet and feeding regime on the growth, food conversion and survival of striped bass fingerlings cultured in ½"-mesh cages suspended in brackish water.

Feeding Regime	Diets	
	Purina Trout Chow	Ground Fish[1]/
Twice daily at 8:00 A.M. & 5:00 P.M.	2[2]/	2
Four times daily at 8:00 and 11:00 A.M. & 2:00 and 5:00 P.M.	2	2

1/A mixture of ground industrial fish (70% by weight) and soybean meal (30% by weight).
2/Number of replications (cages); stocking rate = 30 fish/cage.

In pond culture of striped bass fry to fingerlings at the Edenton National Fish Hatchery, survival rates were much better when ground herring was used as a supplemental feed (Bowker et al., 1968). In view of this and in hopes of finding an efficient but less costly feed, a ground fish/soybean meal diet was prepared.

The ground fish diet was prepared in the following manner: Industrial fish (mainly menhaden) were purchased from commercial fishermen and frozen. The fish were ground while frozen, mixed with the soybean meal and then put back through the grinder. To retain the natural vitamins in the ground fish, the diet remained frozen until fed to the striped bass. The diet was comprised of 70% by weight ground industrial fish and 30% by weight soybean meal. The second diet consisted of Purina Trout Chow.

Feeding rates were the same in all treatment combinations. Initially, the fish were fed at 10% of their body weight per day. This rate was decreased as the fish grew. Complete inventories were made biweekly to record growth, conversion and survival date and to adjust feeding rates.

Fish in the raceway were inventoried biweekly at which time the raceway was drained and cleared. The fish were fed Purina Trout Chow four times daily at an initial feeding rate of 10% their body weight per day. Feeding rates and amounts were adjusted as under cage culture.

In 1972, six cages, allowing two replications per treatment, were used to evaluate the effects of three stocking densities (100, 200 and 300 fish/yd.^{3}) on the growth, food conversion and survival of striped bass fingerlings to subadults. Fish in all cages were fed Purina Trout Chow twice daily at 3% their body weight per day. The fish were inventoried monthly by weighing a subsample of 10% of the fish from each cage. An accurate record of mortality was kept by removing dead fish as soon as they were observed. Amount of food was adjusted monthly by expanding the weight and number of fish subsampled.

Original plans were to continue this experiment for 90 days (March-May). However, a severe bacterial epizootic caused by *Pseudomonas fluorescens* necessitated the termination of the experiment on 5 May 1972.

RESULTS AND DISCUSSION

Cage and Raceway Culture, 1971

Table 2 summarizes the data taken (under each treatment combination) on striped bass cultured in eight, ½"-mesh cages during 4 August - 2 November, 1971. The average growth, food conversion and percentage survival of the two

replications of each treatment combination is presented in Table 3. Figure 3 graphically illustrates average growth for the two replications (cages) of fish under the four treatment combinations. The total weight gained, overall conversion and percentage survival between fish fed the two diets is presented below:

	Total Wt. Gained (g)	Conversion	% Survival
Purina Diet	9,951.4	2.1	97.4
Ground Fish Diet	2,478.9	5.8	85.8

The fish fed Purina Trout Chow had an average weight gain per fish of 0.98 grams per day. In comparison, those fed the ground fish diet had a gain of 0.28 grams.

Salinity during the culture period ranged from 10.0 - 24.4 ppt with an average of 19 ppt.

In comparing the two diets, it is apparent that growth, conversion and survival rates were much better on Purina Trout Chow. The following reasons are given as possible causes for the inferior growth and survival among fish fed the ground fish diet; (1) Unknown nutritional deficiencies of the diet, i.e., absence of vitamins, minerals or amino acids essential for good growth within the species; (2) physical characteristics of the diet, i.e., nonhomogeneous mixing of the ground fish and soybean meal, improper size of the food particles, lack of palatibility or digestibility, lack of suitability to the cage environment (particles tended to sink and float out of the cages more readily than the trout chow pellet).

Except for the conversion rate of 2.1 among fish fed the trout chow, the feeding regime of four times daily acted to enchance growth, conversion and survival rates among fish fed either of the two diets Table 3). Again, inferior results obtained on the ground fish diet were due to the above mentioned reasons.

Although a small stocking density (30 fish/yd.^{3}) was used, the results indicate that excellent growth, conversion and survival rates can be obtained among striped bass stocked in ½" mesh cages and fed multiple daily feedings of Purina Trout Chow. With further modifications of the current cage design, it is possible that a less expensive sinking pellet could produce similar results.

Table 4 summarizes the data taken on striped bass production in the 760-gallon circular raceway. The fish gained a total of 8,151.3 grams during the 93 days in the raceway. This amounts to an 832.1% increase in weight. Overall food conversion and percentage survival was 2.0 and 94.1, respectively. Production in the raceway was comparable to that in the most productive cage (Cage #2). No parasite and disease or low dissolved oxygen problems occurred during the period. In reference to maintenance problems, it is estimated that 50% fewer man-hours were required in maintaining the raceway as compared to maintaining one of the ½" mesh cages.

Table 2. Summary of data taken on striped bass cultured in ½" mesh floating cages and fed Purina Trout Chow and ground fish during August 4- November 2, 1971 (90-day period.).

Cage Number and Treatment*	Date Stocked [1]/ and Sample Dates						Overall % Survival	Overall Conversion
1-GF, 4 x daily	8/4[1]/	8/20	9/9	9/23	10/12	11/2		
No. fish/yd³	30	29	28	28	28	28		
Feeding Rate (%)2/	9.8	9.2	7.9	4.7	5.0	--		
Feeding Rate (%)3/	--	8.9	8.5	5.1	4.5	4.0		
Average Wt. (g)	18.9	21.6	24.3	37.4	39.5	49.6		
Total Wt. (g)	567.0	626.0	680.4	1,047.8	1,106.8	1,388.0		
Conversion Rate4/	--	14.2	20.2	1.9[5]/	15.1	4.0		5.7
% Survival4/	--	96.7	96.6	100.0	100.0	100.0	93.3	
3-GF, 4 x daily	8/4[1]/	8/20	9/9	9/23	10/12	11/2		
No. fish/yd³	30	30	30	30	30	30		
Feeding Rate (%)2/	9.7	8.7	11.5	4.7	5.0	--		
Feeding Rate (%)3/	--	7.6	7.2	7.6	4.6	3.8		
Average Wt. (g)	14.7	18.9	22.7	34.0	34.9	46.3		
Total Wt. (g)	440.0	567.0	680.4	1,020.6	1,047.8	1,388.0		
Conversion Rate4/	--	5.0	8.3	3.0[5]/	31.8	3.2		4.8
% Survival 4/	--	100.0	100.0	100.0	100.0	100.0	100.0	
6-GF, 2 x daily	8/3[1]/	8/20	9/9	9/23	10/12	11/2		
No. fish/yd³	30	30	29	28	26	22		
Feeding Rate(%)2/	9.6	9.7	7.3	4.7	5.1	--		

Feeding Rate(%)3/	--	7.3	8.0	6.2	4.3	4.4		
Average Wt. (g)	8.5	11.3	14.1	17.2	20.2	27.6		
Total Wt. (g)	256.3	340.2	408.2	480.8	526.2	607.8		
Conversion Rate4/	--	4.4	9.2	5.3	9.0	13.5		8.2
% Survival4/	--	100.0	96.7	96.6	92.8	84.6	73.3	
7-GF, 2 x daily	8/3[1]/	8/20	9/9	9/23	10/12	11/2		
No. fish/yd³	30	28	26	26	25	23		
Feeding Rate(%)2/	9.8	8.7	7.0	4.7	4.8	--		
Feeding Rate(%)3/	--	8.4	7.8	5.9	4.3	3.5		
Average Wt. (g)	9.4	11.7	14.0	16.4	18.7	27.8		
Total Wt. (g)	281.2	326.6	362.9	426.4	467.2	639.6		
Conversion Rate4/	--	9.1	14.9	5.2	8.9	2.7		5.9
% Survival4/	--	93.3	92.8	100.0	96.2	92.0	76.7	
2-TC, 4 x daily	8/4[1]/	8/20	9/9	9/23	10/12	11/2		
No. fish/yd³	30	30	30	29	29	29		
Feeding Rate(%)2/	9.9	9.0	4.9	4.7	5.0	--		
Feeding Rate(%)3/	--	6.2	5.4	4.3	3.0	3.4		
Average Wt. (g)	20.3	32.0	52.9	62.6	97.8	142.6		
Total Wt. (g)	607.8	961.6	1,587.6	1,814.4	2,835.0	4,136.8		
Conversion Rate4/	--	2.6	2.6	4.5[5]/	1.5	2.2		2.3
% Survival 4/	--	100.0	100.0	96.7	100.0	100.0	96.7	
4-TC, 4 x daily	8/3[1]/	8/20	9/9	9/23	10/12	11/2		

No. fish/yd³	31	31	31	31	31	31		
Feeding Rate(%)2/	9.9	8.9	6.2	4.7	5.0	--		
Feeding Rate(%)3/	--	6.6	4.3	5.5	2.8	3.4		
Average Wt. (g)	9.4	14.7	27.8	31.2	53.4	84.0		
Total Wt. (g)	281.2	421.8	861.8	966.2	1,642.0	2,435.8		
Conversion Rate4/	--	3.0	1.6	6.7[5]/	1.2	2.1		2.0
% Survival4/	--	100.0	100.0	100.0	100.0	100.0	100.0	
5-TC, 2 x daily	8/3[1]/	8/20	9/9	9/23	10/12	11/2		
No. fish/yd³	30	29	29	29	29	29		
Feeding Rate(%)2/	9.6	8.6	6.9	4.7	4.9	--		
Feeding Rate(%)3/	--	6.3	4.9	5.8	3.0	3.3		
Average Wt. (g)	10.4	16.6	29.7	35.2	55.7	82.6		
Total Wt. (g)	313.0	480.8	861.8	1,020.6	1,614.8	2,395.0		
Conversion Rate4/	--	2.7	2.1	4.9	1.5	2.1		2.2
% Survival4/	--	96.7	100.0	100.0	100.0	100.0	96.7	
8-TC, 2 x daily	8/3	8/20	9/9	9/23	10/12	11/2		
No. fish/yd.³	30	29	29	29	29	29		
Feeding Rate(%)2/	9.8	8.9	6.8	4.7	5.0	--		
Feeding Rate(%)3/	--	6.5	4.7	5.3	3.0	3.2		
Average Wt. (g)	9.4	14.5	27.4	35.2	54.3	85.1		
Total Wt. (g)	281.2	421.8	793.8	1,020.6	1,574.0	2,467.6		
Conversion Rate4/	--	2.9	1.9	3.1	1.6	1.8		2.0
% Survival4/	--	96.7	100.0	100.0	100.0	100.0	96.7	

*GF - Ground fish and soybean mixture; TC-trout chow; 4 x daily - four times daily; 2 x daily - two times daily.

2/ Feeding rate at beginning of period. These rates reflect actual amount of feed fed over the number of days available during the period. Fish were not fed on sampling dates.

3/ Feeding rate at end of previous period.

4/ Since previous sampling date.

5/ In cages 1 through 4, the diet was accidently reversed during one week of the period causing conversion rates to decrease among fish fed ground fish and increase among fish fed trout chow.

Table 3. Average growth, food conversion and percentage survival (of the two replications of each treatment combination) of striped bass cultured in eight, ½" mesh cages suspended in brackish water.

Treatment Combination	Averages of the two replications Wt. (g) per fish at stocking	Wt. (g) per Fish on 2 Nov.	Total wt. Gained (g)	Conversion	% Survival
Purina, 4 x daily	14.8	113.2	2,841.8	2.1	98.3
Purina, 2 x daily	9.9	83.8	2,134.2	2.1	96.6
GF/SB, 4 x daily[1]/	16.8	48.0	884.5	5.2	96.6
GF/SB, 2 x daily	9.0	27.7	355.0	6.3	75.0

1/Ground fish/soybean meal, fed four times daily.

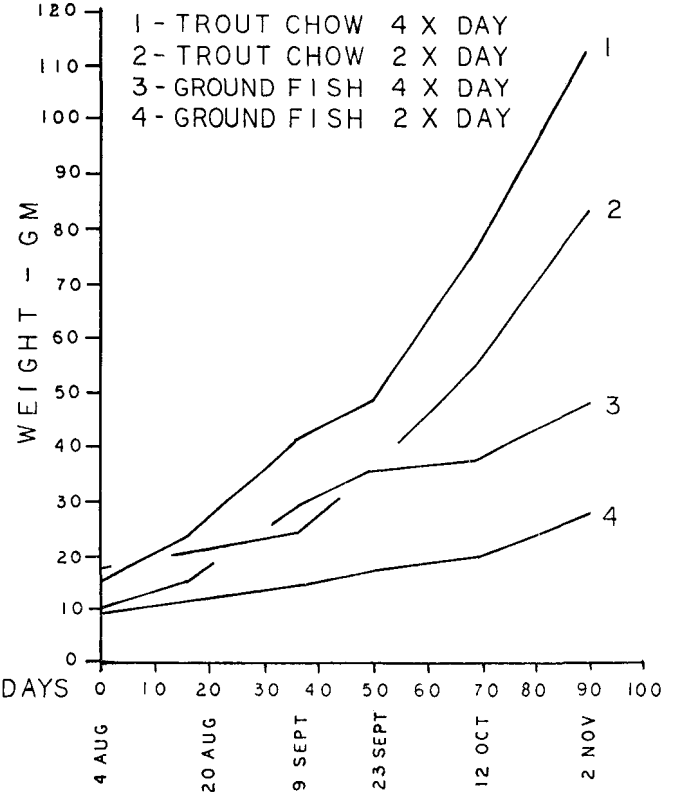

Figure 3. Average weight gained of striped bass at each sampling date under four treatment combinations during culture in yd³ cages.

Table 4. Summary of data taken on striped bass production in a 760-gallon circular raceway during August 3 - November 5, 1971 (93 day period). The fish were fed Purina Trout Chow four times daily.

Parameter	Date Stocked[1]/ and Sample Dates						Overall % Survival	Overall Conversion
	8/3[1]/	8/20	9/7	9/22	10/12	11/5		
No. Fish	102	99	99	99	98	96		
Feeding Rate(%)2/	9.9	8.7	7.6	5.6	3.6	--		
Feeding Rate(%)3/	--	6.0	4.5	5.3	4.3	2.2		
Average Wt. (g)	9.6	16.2	31.0	44.1	57.7	95.1		
Total Wt. (g)	979.6	1,605.7	3,070.9	4,368.2	5,651.8	9,131.0		
Conversion Rate4/	--	2.3	1.6	2.5	3.6	1.3		2.0
% Survival4/	--	97.0	100.0	100.0	99.0	97.9	94.1	

2/ Feeding rate at beginning of period. These rates reflect actual amount of feed fed over the number of days available during the period. Fish were not fed on sampling dates.

3/ Feeding rate at end of previous period.

4/ Since previous sampling date.

From these data, raceway culture of striped bass in brackish water appears very promising.

Cage Culture, 1972

Table 5 summarizes the results of a pilot study to determine optimum stocking rates for striped bass in 1 yd.^{3} cages. The average weight gained per fish per day, food conversion and percentage survival of the two replications under each stocking density is presented below:

	No. fish per yd.^{3} cage			
	100	200	300	Mean
Wt. gained/fish/day (g)	2.3	2.2	1.6	2.0
Food conversion	1.64	1.88	2.44	1.99
Percentage survival	99.5	98.5	99.0	99.0

Excellent survival was obtained at all three stocking rates. Since survival is the most important factor concerning the rearing of striped bass fingerling for stocking into reservoirs and estuaries, survival rates comparable to fresh water pond culture can be obtained in cages stocked as high as 300 or more fingerling per yd.^{3}. It is not realistic to compare these stocking rates/yd.^{3} to those used in pond culture because even at the lowest density of 100/yd.^{3} this would amount to 616,561 fish when expanded on a per surface acre basis.

Standing crops in the two cages stocked at 300 fish/yd.^{3} each were 68.7 kg (151.4 lbs.) and 69.6 kg (153.4 lbs.) and there was no indication that the growth rate of the fish had decreased in either cage at the end of the 60-day period. This indicates that the maximum carrying capacity of the cage was not reach at standing crops of approximately 68.0 kg (150 lbs.)

This experiment demonstrates that striped bass can be grown from an initial weight of 126.1 g (0.30 lb.) to a final weight of 226.8 g (0.5 lb.) with excellent survival rates in 60 days when stocked in cages at a density of 300 fish per yd.^{3}. Since maximum carrying capacity of the cages was not reached, more than 300 fish could be stocked per yd.^{3} cage and yet produce fish 226.8 g (0.5 lb.) or larger. Results of brackish water cage culture of rainbow trout at the Marine Resources Laboratory also showed that the maximum carrying capacity of the cage was not reached at stocking rates of 300/yd.^{3} (Tatum unpublished).

The major detrimental effect that the higher stocking densities had on production parameters was that of increased food conversion. As competition for the food increased the converting efficiency of the species decreased. It is felt that the conversion rates obtained in this experiment can be improved with further modification of feeding ring design.

Observations at the Marine Resources Laboratory during 1971 and 1972 indicate that bacterial diseases, involving the marine form of pseudomonads, chrombacter and flavobacter may be a major limiting factor to the culture of striped bass in a marine environment. Since the marine forms apparently have a higher drug resistance threshold than the freshwater forms, research to develop reliable techniques for marine fish pathogens is much needed.

Table 5. Summary of date taken on striped bass fingerling cultured in ½" mesh cages (1 yd.) during 7 March - 5 May 1972 (60 days). All fish were fed Trout Chow twice daily at 3% their body weight per day.

	Stocking Density (No. fish/yd.^{3} cage)					
	100		200		300	
	Replications		Replications		Replications	
	1	2	1	2	1	2
Avg. wt. fish stocked (g)	136.1	131.5	149.7	136.1	131.5	145.2
Total wt. fish stocked (kg)	13.8	12.9	29.9	27.0	39.4	42.9
Total amt. feed fed (kg)	22.8	22.1	51.2	48.9	66.6	68.9
Avg. wt. fish on 5 May (g)	275.0	268.7	296.5	262.9	232.7	230.0
Total wt. fish on 5 May (kg)	27.5	26.6	58.4	51.8	69.6	68.7
Total wt. gained (kg)	13.7	13.7	28.5	24.8	30.2	25.8
Conversion rate	1.66	1.61	1.80	1.97	2.21	2.67
Percentage survival	100.0	99.0	98.5	98.5	99.7	98.3

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