Evaluation of Optimum Stocking Rate of Striped Bass x White Bass Fry in Hatchery Rearing Ponds

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Abstract: The optimum stocking rate in hatchery rearing ponds was determined for female striped bass (*Morone saxatilis*) X male white bass (*Morone chrysops*) hybrid fry that would yield the highest number of fingerlings/ha of acceptable size and condition. Five fry stocking rates ranging from 494,000 to 2,470,000/ha were tested to determine the effect on number of fingerlings produced, average total length, average weight/1,000, total weight, and condition. The optimum stocking rate was calculated to be 1,875,000 fry/ha, which would yield 537,000 fingerlings/ha. Average total length and average weight/1,000 fingerlings was 25.4 mm and 191.7 g, respectively, at the optimum stocking rate. Total weight and condition of the fingerlings produced were not affected by the 5 stocking rates. Efforts to maximize production of acceptable quality fingerlings has become an economic necessity as the demand for *Morone* fingerlings in Georgia has increased.

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Fish culturists have stocked striped bass and *Morone* hybrid fry in hatchery rearing ponds at widely varying rates. Harper and Jarman (1971) tested striped bass fry stocking rates from 24,700 to 395,200/ha during a 3-year period. They indicated that the maximum fry stocking rates may not have been attained based on the lack of stunting or decrease in percent survival.

Braschler (1974) recommended striped bass fry stocking rates at federal hatcheries should be between 197,600 and 247,000/ha. Fry stocking between

123,500 and 494,000/ha, with 247,000/ha being the accepted optimum rate, were recommended by Bonn et al. (1976).

Parker (1979) stocked striped bass fry in continuously aerated rearing ponds at 250,000, 500,000, and 1,000,000/ha. He found the total number of fingerlings harvested after 44 days of rearing was not greatly different from the stocking densities; however, size, weight, and percent survival did differ among the stocking rates.

The different *Morone* fry stocking rates used by the various fingerling-producing agencies have resulted in part from fry availability, size of fingerlings desired, potential pond productivity, and available pond space. The agencies' inconsistency in stocking rates needed to be addressed scientifically in order to aid culturists in maximizing production and survival expectations.

Because of an increasing demand for *Morone* fingerlings and a decrease in available state hatchery pond acreage in Georgia, the need to maximize production of quality size fingerlings for stocking reservoirs, rivers, and estuaries has become increasingly important. Currently, Georgia's goal is to produce a fingerling $\geqq$ 25.4 mm, in good condition, within 45 days.

In 1979, Georgia's biologists increased the *Morone* fry stocking rate at all state hatcheries from 494,000 to 741,000/ha based on regression analysis of previous pond production data. The regression for hybrids indicated the apparent maximum production of fingerlings would occur at a fry stocking rate of 1,069,000/ha. However, statewide fry stocking rates were set at 741,000/ha until more was learned about *Morone* pond culture and fry stocking rates.

The objective of this study was to determine the optimum stocking rate for striped bass × white bass hybrid fry in Georgia's hatchery rearing ponds that would yield the highest number of fingerlings/ha of an acceptable size (25.4 mm minimum) and condition.

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Methods

During April and May 1981, 12 small rearing ponds (11, 0.08 ha; and 1, 0.12 ha) at Richmond Hill Fish Hatchery, Richmond Hill, Georgia, were used to evaluate the production of striped bass × white bass hybrid fry at stocking rates of 494,000, 988,000, and 1,482,000/ha. In April and May 1982, stocking rates of 1,482,000, 1,976,000, and 2,470,000/ha were tested in the same ponds. Four ponds were randomly selected for each stocking rate.

Striped bass × white bass hybrid fry (6.5 days old) from 6 different broodfish in 1981 and 3 broodfish in 1982 were pooled in a fry holding trough and then transferred to 12 113.5 liter aquaria, each representing an experimental pond. The aquaria were subsampled to estimate the number of fry in each aquarium and, if necessary, adjusted to the correct pond stocking rate. The fry were transported in plastic garbage cans after dark to their respective ponds, where they were tempered for one-half hour prior to release into the ponds. [All ponds were stocked simultaneously.]

Standard *Morone spp.* culture practices used at Georgia hatcheries were followed during the experiment. Applications of algicides, organic and inorganic fertilizers, and diesel fuel for aquatic insect control were applied equally to all experimental ponds to reduce variability among the ponds. Water quality (temperature, dissolved oxygen, pH, carbon dioxide, total hardness, and total alkalinity) was monitored at 4-day intervals throughout the rearing period using a Hach pH kit, YSI dissolved oxygen meter, and a laboratory titration system to detect any problems that might cause mortality.

Fingerlings were harvested from the ponds at 42 days of age and placed in separate holding vats containing a 1.0% sodium chloride concentration. After a 3-hour adjustment period to reduce fingerling stress, the total number, total weight, average total length, and average weight/1,000 fingerlings from each pond were determined.

Statistical analyses comparing fry stocking rates to the number produced, average total length, average weight/1,000, total weight, and condition of harvested fingerlings were conducted to describe the relationships of increased stocking rates to hybrid fingerling production. These statistical methods included Student's *t*-test, linear regression, curvilinear regression (asymptotic and quadratic), and analysis of variance (ANOVA). The level of significance for all statistical tests was set at $\alpha = 0.10$.

Results

Number of Fingerlings Produced

The number of *Morone* hybrid fingerlings harvested at the 5 different fry stocking rates indicated the highest percent survival occurred at the 494,000/ha stocking rate while the greatest number of fingerlings were harvested at 1,976,000/ha (Table 1).

A multiple regression was used to fit a second degree polynomial of the form $y = a + bx + cx^2$ to the production data, which resulted in a quadratic regression of $y = -198{,}455.81 + .78x - (2.08 \cdot 10^{-7})x^2$ (Fig. 1). The test of curvature of the quadratic regression was significant ($P = 0.01$) and was used to describe the response of the number of fingerlings produced from various stocking rates.

The optimum stocking rate or number of fry/ha required to produce the maximum number of fingerlings was determined by setting the first derivative of the above equation equal to 0, and solving for x. The optimum stock-

Table 1. Mean (± SE) fingerling production data from 5 *Morone* hybrid fry stocking rates.

Year	Fry stocked (*N*/ha)	Fingerlings harvested (*N*/ha)	Survival (%)	Average total length (mm)	Average weight (g/1,000)	Total weight (kg/ha)	Condition factor (k)
1981	494,000	177,476 ± 31,435	35.9 ± 6.4	37.0 ± 3.2	654.4 ± 182.1	100.7 ± 12.5	1.20 ± 0.03
1981	988,000	280,697 ± 45,353	28.4 ± 4.6	26.3 ± 3.2	256.8 ± 82.1	74.0 ± 25.6	1.27 ± 0.10
1981							
	1,482,000	522,784 ± 66,573	35.3 ± 4.5	26.2 ± 1.1	220.4 ± 27.0	105.4 ± 7.4	1.21 ± 0.06
1982							
1982	1,976,000	578,221 ± 80,405	29.3 ± 4.1	28.7 ± 2.0	270.5 ± 67.5	141.8 ± 9.4	1.08 ± 0.07
1982	2,470,000	436,295 ± 36,384	17.6 ± 1.5	25.6 ± 1.7	208.8 ± 55.9	88.8 ± 19.1	1.18 ± 0.08

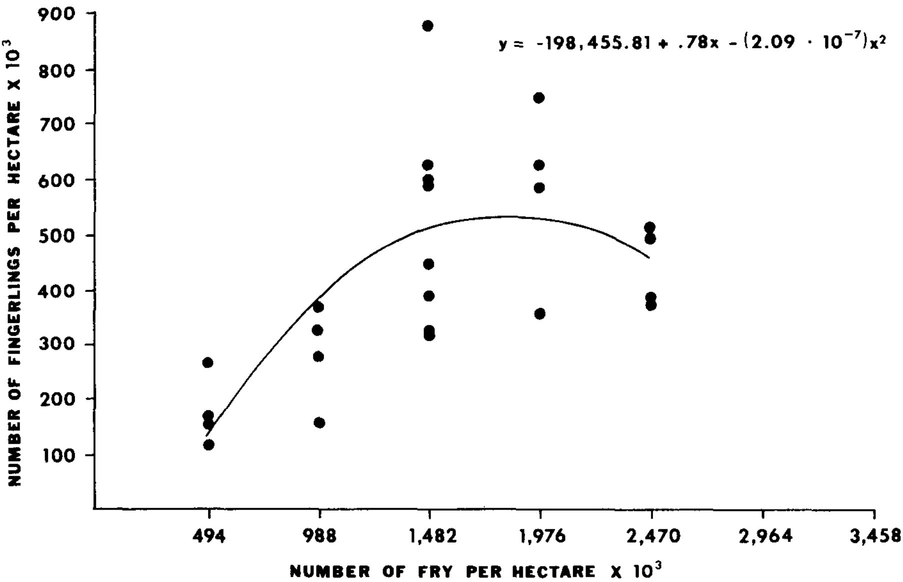

Figure 1. Quadratic regression describing the number of *Morone* hybrid fingerlings produced at 5 fry stocking rates.

ing rate (x = 1,875,000 hybrid fry/ha) was substituted into the above regression resulting in a maximum number of 537,000 hybrid fingerlings/ha.

Average Total Fingerling Length

The average total length of hybrid bass fingerlings harvested from each stocking rate indicated the largest size fingerlings occurred at 494,000 fry/ha, where they averaged 37.0 mm/fingerling (Table 1).

A second degree polynomial was fitted to the data which resulted in the quadratic regression $y = 43.81 - (1.96 \cdot 10^{-5})\,x + (5.22 \cdot 10^{-12})x^2$ (Fig. 2). The test for the significance of curvature of the quadratic regression was significant ($P = 0.04$) and it was used to describe the effect of various fry stocking rates on the average length of hybrid fingerlings.

The stocking density at which the average total length was at a minimum was determined to be 1,877,000, using the first derivative of the above regression. Substituting 1,877,000 fry/ha into the regression for x resulted in a minimum fingerling length of 25.4 mm. When the optimum fry stocking rate of 1,875,000 fry/ha was substituted into this regression, the length of the fingerlings remained at 25.4 mm.

Average Fingerling Weight/1,000

The 494,000/ha fry stocking rate produced the greatest average weight/1,000 of 654.4 grams/1000 fingerlings (Table 1). However, the data were variable within this stocking rate. Therefore, a log transformation was utilized to make the data more closely approximate a normal distribution.

A second degree polynomial was fitted to the data which resulted in a quadratic regression $\log y = 3.06 - (8.10 \cdot 10^{-7})x + (2.11 \cdot 10^{-13})x^2$ (Fig. 3). The test of curvature of the regression was significant ($P = 0.06$). Therefore, the regression was used to describe the relationship between the 5 stocking rates and average weight/1,000 fingerlings. The stocking density at which the average fingerling weight/1,000 was at a minimum was determined to be 1,919,000, using the first derivative of the above regression. Substituting 1,919,000 fry/ha into the regression produced a minimum weight of 191.7 g/1,000 fingerlings. The same weight resulted when the optimum stocking rate (1,875,000) was substituted into the regression.

Total Fingerling Weight

The weight of fingerlings produced from each fry stocking rate indicated that the 1,976,00 fry/ha stocking rate produced the greatest weight of 141.8 kg/ha (Table 1).

A second degree polynomial was fitted to the data. The test of curvature was not significant ($P = 0.50$); therefore, the quadratic regression was rejected. A linear regression of the form $y = a + bx$ was then fitted to the data,

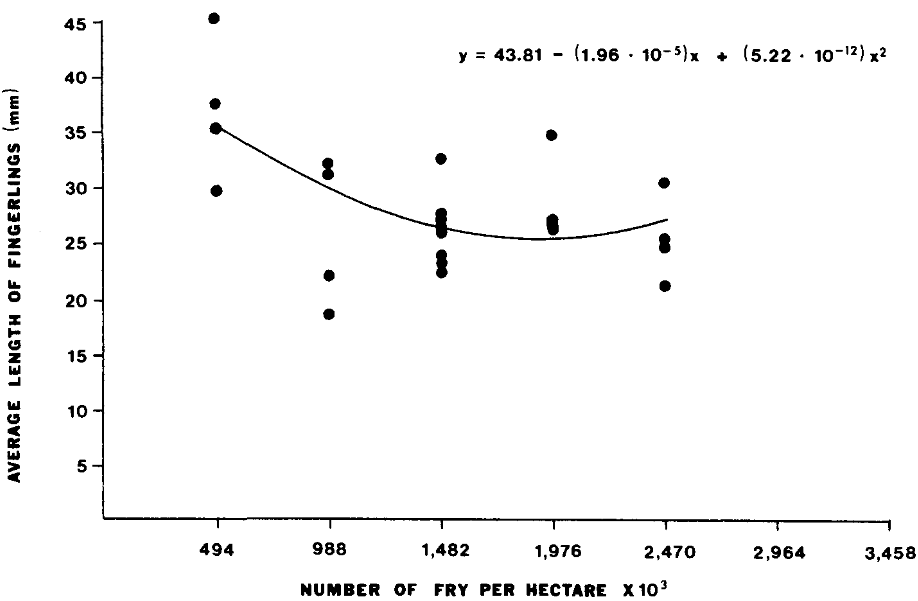

Figure 2. Quadratic regression describing the average total length of *Morone* hybrid fingerlings produced at 5 fry stocking rates.

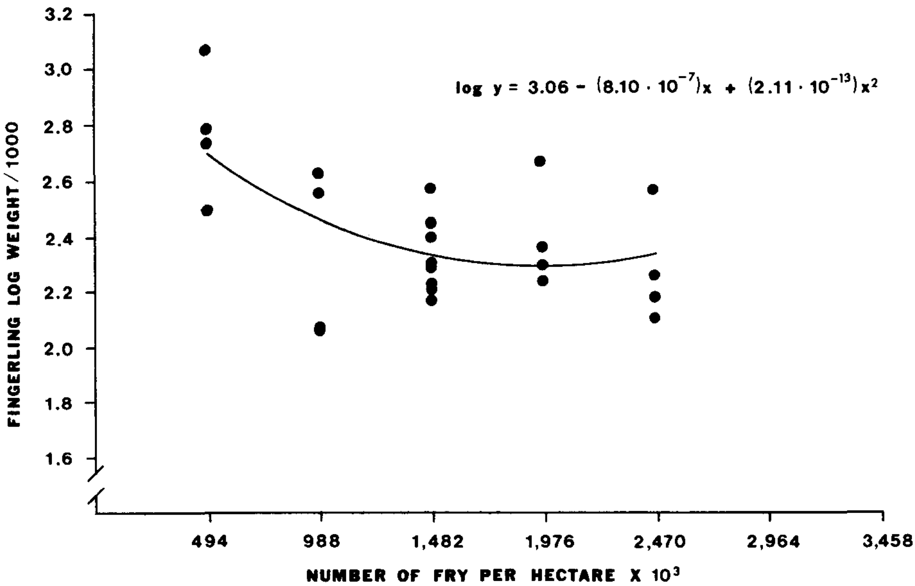

Figure 3. Quadratic regression describing the average weight/1000 *Morone* hybrid fingerlings produced at 5 fry stocking rates.

but the regression was not significant ($P = 0.47$). Therefore, the hypothesis: $b = 0$, when b represents the slope, was accepted. Thus, a horizontal line through $y = 102.7$ kg/ha best described the data (Fig. 4).

Fingerling Condition Factor

The final relationship of condition factor (K) response to changing stocking rates did not reveal any obvious trends (Table 1).

A second degree polynomial was fitted to the data. The test of curvature was not significant ($P = 0.92$); therefore, the quadratic regression was rejected. A linear regression was then fitted to the data and tested for significance. It was not significant ($P = 0.36$). Therefore, the hypothesis: $b = 0$ was accepted and a horizontal line through $y = 1.19$ was determined to best describe the data (Fig. 5).

Discussion

The total number of *Morone* hybrid fingerlings harvested after 42 days in the rearing ponds was significantly greater at the higher fry stocking rates tested in this experiment. The number of fingerlings harvested at the 1,976,000/ha stocking rate increased 326% when compared with the number of finger-

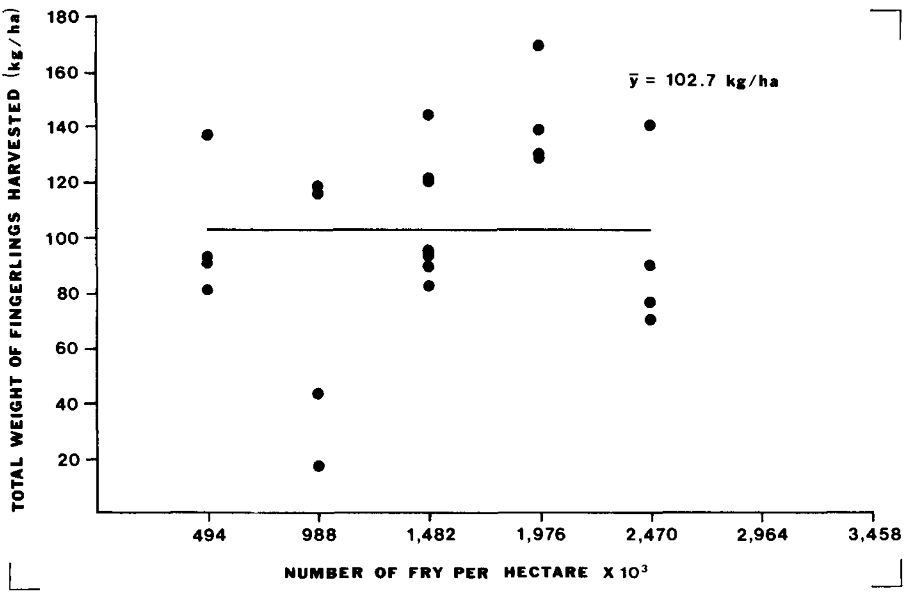

Figure 4. Relationship between the total weight of *Morone* hybrid fingerlings produced and 5 fry stocking rates.

lings harvested from ponds stocked at the 494,000/ha rate. However, the highest percent survival and the largest fingerlings, both in average total length and average weight/1,000 occurred at the lowest stocking rate (494,000 fry/ha).

The optimum hybrid fry stocking rate was statistically calculated to be 1,875,000 fry/ha, and the number of fingerlings which could be expected at the optimum rate was determined to be 537,000 fingerlings/ha. The expected average total length and average weight/1,000 fingerlings at the optimum stocking rate were calculated at 25.4 mm and 191.7 g, respectively. The average fingerling total length and average weight/1,000 were inversely related to the number of fingerlings harvested. Therefore, stocking rates can be manipulated to obtain a certain size fingerling, specific weight/1,000, maximum production, or a combination of all 3. It is important to remember that these relationships will probably vary with changes in length of the rearing period, climate, food supply, etc.

The total weight of the fingerlings produced at each fry stocking rate was calculated to be consistent at 102.7 kg/ha. It could be inferred that 102.7 kg/ha was the carrying capacity of the ponds used in this experiment. The average condition factor ($K = 1.19$) of the fingerlings also did not differ significantly among stocking rates. Therefore, while average total length and average weight/1,000 were related to stocking rates, the total weight and condition of the fingerlings produced were not affected by the number of fry stocked in ponds at Richmond Hill Hatchery.

Georgia's overall objective is to rear as many *Morone* fingerlings as possible within 45 days, at least 25.4 mm in length, and in good condition. The results of this study showed that stocking 1,875,000 fry/ha should produce 537,000 fingerlings/ha in good condition within a suitable rearing period (42 days). Since fry production is not a limiting factor in hatchery production in Georgia, utilization of the optimum fry stocking rate should help to maximize fingerling production within a limited hatchery pond system.

Georgia currently stocks *Morone* fingerlings ≥ 25.4 mm in reservoirs, rivers, and estuaries. We acknowledge that fingerlings larger than 25.4 mm probably have a better chance of survival, but the current practice has been successful in Georgia reservoirs as evidenced by population surveys and creel harvest records. Because of an increased demand for *Morone* fingerlings and a limited rearing pond availability, Georgia biologists are faced with producing maximum numbers of fish/rearing pond. Increasing the size of fingerlings produced would necessitate lower fry stocking rates resulting in lower rearing pond harvests (Bailey 1974, Bonn et al. 1976).

The optimum hybrid fry stocking rate derived in this experiment can best

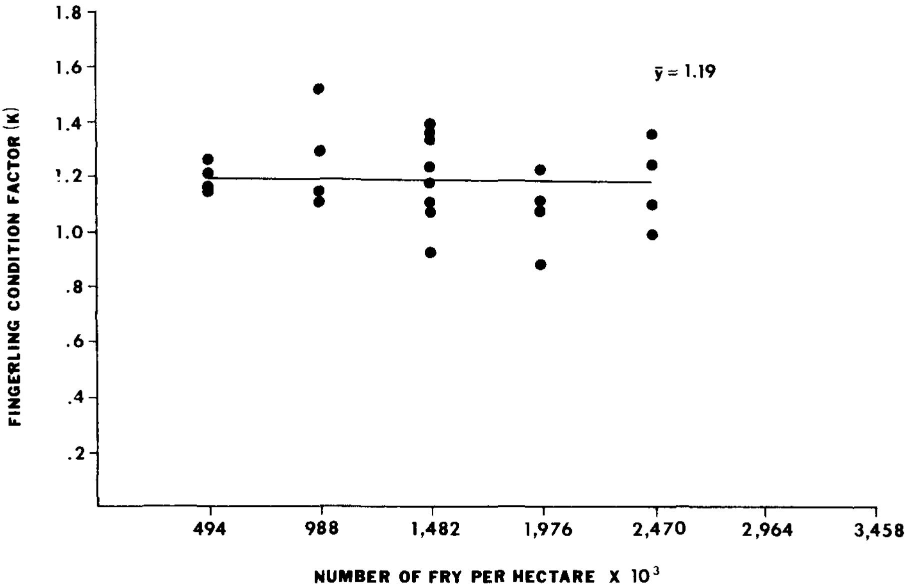

Figure 5. Relationship between the condition of *Morone* hybrid fingerlings produced and 5 fry stocking rates.

be interpreted as a starting point for other *Morone* culturists. Differences in fingerling stocking objectives, cultural techniques, and hatchery pond conditions in various geographical areas may affect the optimum fry stocking rate reported. It is likely that differences also exist between the optimum stocking rate of striped bass and *Morone* hybrid fry. Today's rising costs, tighter funding, and limited hatchery pond acreage necessitates that managers maximize production with the resources at hand.

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