Use of Additional Calcium in Soft-water Ponds for Improved Striped Bass Survival

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Abstract: Fingerling production and post-harvest survival were compared for striped bass (*Morone saxatilis*) produced in ponds with low (<2 mg/liter) levels of calcium and in ponds where calcium was increased (14–40 mg/liter) by the addition of calcium chloride. Production pond calcium levels were not correlated with fry survival, or biomass production in ponds. Post-harvest survival of fingerlings from treated ponds was significantly better than post-harvest survival of fish from control ponds.

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During May 1983 a non-infectious disease killed 83% of 5-week-old striped bass (*Morone saxatilis*) and 100% of the hybrid bass (*M. chrysops* × *M. saxatilis*) harvested at Georgia's McDuffie and Walton fish hatcheries, respectively. The disease was characterized by acute tetany, hemorrhages associated with broken vertebrae and erratic swimming followed by lethargy. Clinical signs were manifested at 3-h post-harvest while fish were being held in vats prior to stocking in reservoirs. Increasing calcium levels of holding waters with calcium chloride improved post-harvest survival of these species, while one percent sodium chloride solutions failed to reduce mortalities (Grizzle et al. 1985). These findings were further investigated during 1985.

The 1985 study had two major objectives: (1) to evaluate increased calcium levels in culture ponds for improving fingerling striped bass production; (2) to compare post-harvest survival rates of fingerlings reared with additional calcium to those reared in water without increasing calcium levels. Calcium chloride was applied to 4 of 7 culture ponds 24 hours prior to fry introductions to evaluate the effects of additional calcium on striped bass production. Static bioassays using waters with low and high calcium levels were used to evaluate post-harvest survival of striped bass fingerlings.

Methods and Materials

Walton Hatchery is located on the Southern Piedmont in Walton County, Georgia. Soil types are characterized as clay-loam. McDuffie Hatchery is situated on the Upper Coastal Plain in McDuffie County, Georgia. Soil types are described as sandy-loam. Water characteristics of the 2 hatcheries are presented in Table 1. Similarities between the 2 facilities include culture waters which are low in calcium (<2 mg/liter).

Pond Performance

Seven culture ponds (0.24–0.34 ha) were filled 1 to 3 weeks prior to fry stockings. Plankton blooms were established and maintained by applying cottonseed meal and inorganic fertilizers. Calcium in culture waters was increased to 2.5 ± 0.4 mg/liter (SD) by applying $Ca(OH)_2$ or $CaCO_3$ directly to culture ponds (Walton) or the water source (McDuffie), respectively. On 15 April 1985, 60 mg/liter of calcium using calcium chloride as the source was applied to 1 McDuffie (M17A) and 2 Walton (W9, W11) ponds. A second McDuffie pond (M15A) received 30 mg/liter of calcium. The remaining ponds, 1 at Walton (W4) and 2 at McDuffie

Table 1. Analysis of the water supplies at Walton and McDuffie Hatcheries, Georgia.

Parameters	Walton[a]	McDuffie[b]
pH	5.7	6.8
Hardness[c]	8 mg/l	10 mg/l
Alkalinity[c]	6 mg/l	13 mg/l
Ca	1.69 mg/l	1.88 mg/l
Cu	0.01 mg/l	0.04 mg/l
Fe	0.35 mg/l	1.18 mg/l
Pb	0.02 mg/l	0.02 mg/l
Mg	0.93 mg/l	0.94 mg/l
Mn	0.06 mg/l	0.10 mg/l
K	3.70 mg/l	1.34 mg/l
Na	2.40 mg/l	2.19 mg/l
Zn	0.05 mg/l	0.11 mg/l

[a]Spring.
[b]Reservoir.
[c]As $CaCO_3$.

(M13A, M14A) were not treated with calcium chloride. Equal applications of calcium chloride produced variable levels of calcium in production ponds. Cation exchange capacity of pond muds probably influenced the amount of calcium in the pond waters (Boyd 1979).

Seven-day-old striped bass fry spawned at Georgia's Richmond Hill Hatchery were stocked in rearing ponds at a rate of 741,000/ha on 16 April 1985. Three spawns of fish were pooled to provide a common group of fish for each culture pond. Ponds were drained and fingerlings harvested by seine at the end of a 30- to 35-day culture period.

Physiochemical data including pH, temperature, total hardness, total alkalinity, dissolved oxygen, and Secchi disk visibility were collected on 4-day intervals. Calcium levels were measured every 8 days.

Post-Harvest Performance

Striped bass, which were used in bioassay treatments, were retained in water from their respective culture ponds for a 1-hour post-harvest acclimation period. Samples of fish from each culture pond were placed in $CaCl_2$ solutions of 150 mg/liter or 0 mg/liter which allowed exposure to 4 calcium regimes. Fish from untreated ponds were considered controls if held in 0 mg/liter $CaCl_2$ solutions and vat treated if held in 150 mg/liter solutions. Fish from treated ponds were termed pond treated if held in 0 mg/liter $CaCl_2$ and pond/vat treated if placed in 150 mg/liter solutions. Test vessels were 378-liter insulated aluminum tanks aerated with compressed air. Two replicates of the possible treatments from each pond were made with a minimum of 50 fish, with the exception of 1 pond (W9) where production totaled 93 fish. Average total length of fingerlings at harvest ranged from 25.4 to 34.6 mm.

At the end of a 6-hour period, moribund and dead fish were counted. Moribund fish were those displaying abnormal behavior (i.e. tetany, spiraling and lethargy). The moribund fish were combined with the dead for statistical analysis. Additionally, each fish was examined, with the aid of a lighted map table, for hemorrhagic areas in the tail-trunk region.

Water quality of the tanks was monitored at the initiation and termination of the test period. Water samples for calcium determination were collected at the end of the test period and prepared for analysis by atomic absorption.

Chi-square analysis was used to test for difference between treatments. An alpha level of $P \leqslant 0.05$ was accepted as significant.

Results and Discussion

Earlier work suggested that fingerling mortalities were related to the stress response (Mazeaud et al. 1977) following harvest. An increase in cortiocosteroids (Davis et al. 1982) increased gill permeability which produced osmoregulatory complications. As a result, fish were unable to maintain a sufficient level of calcium with existing water quality. Therefore, muscle functions were impaired which re-

Table 2. Striped bass production pond data for Walton (W) and McDuffie (M) Hatcheries, Georgia, 1985. Standard deviations are shown in parenthesis.

Pond	Mean calcium (mg/l)	Survival (%)	Fish/ha	kg/ha	Mean length (mm)
W4	3	14	105,720	9	25.2
	(0.5)				(2.9)
W9	27	<1	410	0.07	30.2
	(6.9)				(3.5)
W11	40	27	193,356	33	23.3
	(9.4)				(3.8)
M13A	2	25	184,690	63	28.6
	(0.6)				(3.3)
M14A	2	45	333,005	111	29.7
	(0.2)				(3.9)
M15A	14	41	301,933	118	29.7
	(5.6)				(5.7)
M17A	17	4	33,150	17	34.6
	(3.5)				(3.3)

Table 3. Average water quality in striped bass ponds at Georgia's Walton (W) and McDuffie (M) Hatcheries, 1985. Standard deviations are shown in parenthesis. Measurements were made at 4-day intervals for approximately 40 days.

Pond	Temp. (°C)	pH	Total hardness (mg/l)[a]	Total alkalinity (mg/l)[a]	Dissolved oxygen (mg/l)	Secchi disk (cm)
W4	23.8	7.2	13	33	8.0	66.3
	(2.6)	(0.8)	(3.2)	(6.7)	(2.1)	(14.6)
W9	22.8	7.8	74	29	8.8	60.2
	(3.4)	(1.2)	(8.1)	(7.9)	(3.0)	(24.7)
W11	23.0	8.1	110	34	8.6	53.1
	(2.9)	(0.9)	(15.9)	(7.3)	(1.9)	(12.4)
M13A	24.8	7.5	9	22	7.4	41.4
	(3.4)	(1.1)	(0.8)	(3.2)	(1.2)	(21.7)
M14A	24.5	7.6	10	22	7.6	39.6
	(3.6)	(1.0)	(0.8)	(4.3)	(0.7)	(6.8)
M15A	26.7	7.4	39	23	7.3	59.9
	(3.4)	(1.1)	(7.7)	(3.3)	(0.7)	(17.7)
M17A	26.6	7.3	49	21	7.3	67.1
	(3.5)	(0.8)	(10.8)	(3.4)	(1.0)	(15.7)

[a]As $CaCO_3$.

sulted in the death of the fish. The vertebral fractures were the result of extreme muscle contractions. The possibility of poorly mineralized bone (Millikin 1982) would have increased the incidence of fracture. Therefore, the primary objective of using additional calcium in production ponds was to prevent fry mortalities which could occur as the result of stocking stress.

Pond performance was evaluated by fish biomass produced, fish survival, and mean length (Table 2). Calcium levels did not show strong correlations with these parameters; variance was large between and within the 2 hatcheries. Overall survival rates were 14.2% for Walton and 28.7% for McDuffie. Walton ponds averaged

Table 4. Survival and occurrence of hemorrhage for striped bass (40-day-old) fingerlings 6-h post-harvest following exposure to 4 calcium regimes in static bioassays at Georgia's Walton and McDuffie Hatcheries, 1985.

	Control[a]	Vat[b]	Pond[c]	Pond/Vat[d]
Survival (%)				
Walton	11	31	78	95
McDuffie	50	63	81	78
Weighted mean	23	43	74	79
Hemorrhage (%)				
Walton	15	24	12	12
McDuffie	14	8	8	2
Weighted mean	14	11	8	4
Number exposed				
Walton	53	74	255	252
McDuffie	413	402	1,076	1,042
Total	466	476	1,331	1,294

[a]Fish were reared in waters containing 2.5 ± 0.4 mg/liter (SD) calcium and held in waters containing 2.2 ± 0.5 mg/liter calcium post-harvest.
[b]Fish were reared in waters containing 2.5 ± 0.4 mg/liter (SD) calcium and held in waters containing 65 ± 17.6 mg/liter calcium post-harvest.
[c]Fish were reared in waters containing 24 ± 11.6 mg/liter (SD) calcium and held in waters containing 2.2 ± 0.5 mg/liter calcium post-harvest.
[d]Fish were reared in waters containing 24 ± 11.6 mg/liter (SD) calcium and held in waters containing 60 ± 32.2 mg/liter calcium post-harvest.

99,800 fish/ha and 14 kg/ha compared with McDuffie's 213,195 fish/ha and 77 kg/ha. Lowest survival occurred in 2 of the ponds with $CaCl_2$ added (one at each hatchery), while the best survival was obtained in a McDuffie control pond. Pond water quality (Table 3) was in favorable ranges with the exception of pond W9 where the pH rose to 9.8, 24 hours after stocking. The elevated pH probably reduced survival in this pond. The reason for low survival in pond M17A is not known.

The highest survival rate (weighted mean) in vats was for fish from the treatment with $CaCl_2$ added to both pond and vat. Survival was similar in the pond/vat and pond only treatments, but significantly different from each other and the two other treatments (Table 4). The incidence of hemorrhage (weighted mean) was lowest in the pond/vat treatment and highest in the control treatment (Table 4). Treatment results were significantly different.

While the fish were held in vats, fish survival in each treatment, with the exception of pond/vat was lower at Walton than at McDuffie (Table 4). Survival was also lower at Walton during 1983. Walton fish also had a consistently higher rate of hemorrhage in each treatment as compared with McDuffie striped bass. The addition of calcium to rearing ponds, however, reduced post-harvest mortalities and hemorrhage at both hatcheries.

Pond results were too variable to provide culture recommendations based solely on production parameters. Many factors interact to influence production regardless of treatment (Shell 1983), and as a result, wide variation in striped bass production ponds is common within and between hatchery systems (Stevens 1984). The data suggest, however, that pond treatment was important for improving post-harvest survival when vat treatment survival (43%) is compared with pond/vat treatment survival (79%).

Higher calcium levels than those used in this study could have improved results. Fish from a Walton pond (W11) with additional calcium (40 mg/liter calcium, measured) showed clinical disease signs (erratic swimming and tetany) at harvest. When the calcium concentration was increased to an estimated 120 mg/liter in the harvest basin, disease signs subsided. Similar abnormalities were noted for McDuffie fish that were being held in 60 mg/liter of calcium for shipment to reservoirs. Disease signs subsided once the calcium concentration was elevated to an estimated 125 mg/liter.

Bioassay results suggest that mortality could increase for fish from the pond/vat treatment when they are stocked in reservoirs with low calcium levels. This should be anticipated since the pond treatment provided an average survival which was 5% less than the pond/vat treatment.

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