Growth and Survival of Juvenile Striped Bass (*Morone saxatilis*) × White Bass (*M. chrysops*) Hybrids Reared at Different Salinities[1]

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Abstract: The striped bass (*Morone saxatilis*) x white bass (*M. chrysops*) hybrid is widely stocked to support recreational fishing and is of interest as a commercial aquaculture candidate. Nevertheless, there is little information concerning the relative performance of these hybrids in various salinities. A replicated 126-day study compared growth, survival, standing crop, and feed conversion of juvenile hybrid bass (mean size 5.8 g) reared under controlled conditions at 0, 7, 14, 21, 28, and 35 ppt salinity. Results indicated that growth was similar at all salinities and that fish survival was high (mean 91.7%) at all salinities except 35 ppt where survival was 60.0%. Feed conversions averaged 1.7 using a pelleted feed and average standing crop was 11.1 kg/m^3 for salinity treatments 0, 7, 21, and 28 ppt. Standing crop was 6.7 kg/m^3 at salinity 35 ppt due to the lower survival rate. A disease outbreak resulted in loss of all fish reared at 14 ppt after day 105. However, up until that time survival was 100%.

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The striped bass (*Morone saxatilis*) and its white bass (*M. chrysops*) hybrids have been stocked in 57% of the total reservoir area in the United States (Stevens 1984) and are highly sought for stocking of privately-owned waters by individuals

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and fishing clubs. These fish have excellent recreational appeal and are often the focus of the nation's fishermen (Watt et al. 1982). In recent years, there has been increasing interest in commercially rearing both the striped bass and its white bass hybrids as food fish (Powell 1973; Valenti et al. 1976; Wawronowicz and Lewis 1979; Williams et al. 1981; Kerby et al. 1983*a, b*; Woods et al. 1983; Carlberg et al. 1984; Collins et al. 1984; Smith and Jenkins 1985*a, b*; Smith et al. 1985). This interest is due in part to the high market demand and value of these fish (Swartz 1984; Gordon 1985). Currently, the wild fishery for striped bass on the Atlantic coast is severely depleted and fishing moratoriums are being imposed in many states (e.g., Maryland, Rhode Island). Such restrictions have further increased the market demand for striped bass and striped bass-like products.

The striped bass/white bass hybrids (original and reciprocal crosses) exhibit rapid early growth, high survival rates, good adaptability to broad environmental conditions, and general hardiness (Bayless 1968, 1972; Bishop 1968; Kerby and Joseph 1979; Ware 1975; Smith and Jenkins 1985*a, b*; Smith et al. 1985). As such, these hybrids are preferred for use in aquaculture operations focused on food fish production. Historically, production of hybrids has been in fresh water but work by Williams et al. (1981) and Woods et al. (1983) demonstrated that the hybrids could be cultured in brackish water. Today, some stocking programs release these hybrids in estuarine and coastal areas (Stevens 1984), and biotelemetry studies suggest that the hybrids prefer brackish water with some tagged fish inhabiting salinities as high as 33 ppt (Yeager 1982). Salinity tolerances of striped bass are well documented and it seems that white bass probably can survive in brackish waters as they have been captured in coastal streams along the Gulf of Mexico (Moyle 1976). In a short term study Wattendort and Shafland (1982) demonstrated that both the original and reciprocal crosses of striped bass/white bass hybrids could survive 36 ppt salinity for at least 7 days and that they could adapt to an abrupt change from fresh water to 36 ppt or vice versa. However, no information exists on the relative performance of the striped bass x white bass hybrids when reared in various salinities.

The purpose of this manuscript is to report the growth, survival, standing crop, and feed conversions of juvenile striped bass x white bass hybrids reared in a laboratory study under controlled salinity conditions. Such information should help identify potential sites for aquaculture development and be of interest to fishery managers as they formulate stocking and management programs for the striped bass x white bass hybrids.

Methods

Hybrids of the striped bass female x white bass male were used in this 126-day study to examine the effect of salinity on production parameters. The experimental fish were obtained as newly hatched fry from South Carolina's Monck's Corner hatchery and reared to a small juvenile size in an indoor intensive nursery system at the Marine Resources Research Institute in Charleston (Smith and Jenkins 1985*b*). At initiation of the study these 101-day-old hybrids had a mean weight of 5.8 g.

A wide range of salinities was selected to simulate inland to oceanic conditions. The salinity treatments were tested in triplicate and consisted of 0, 7, 14, 21, 28, and 35 ppt salinity. The various salinity levels were achieved by adding Instant Ocean brand (Aquarium Systems, Mentor, Ohio) synthetic sea salts to dechlorinated tap water. The experimental culture units were black cylindrical fiberglass tanks having a diameter of 45 cm and total depth of 45 cm. Tanks were fitted with center standpipes and tank bottoms were slightly rounded to assist in waste collection and removal. Actual water volume in the tanks during the study was 55 liters. Each group of 3 tanks was suspended above a common 157 × 45 × 16 cm deep reservoir and biological filter tank. Tanks were housed in a room where photoperiod was maintained at 12 hours light: 12 hours dark with fluorescent lighting.

Initially, hybrid bass were randomly selected and stocked at a density of 10 fish/tank in the experimental culture tanks containing freshwater. Over a period of 5 days, the various salinities were gradually changed to the desired experimental treatment salinities. Fish were then acclimated for 3 weeks in the culture tanks prior to the beginning of the study. To begin the study, the 30 fish from each salinity were pooled, individually weighed on an electronic balance to 0.1 g, and returned to the culture tanks. Mean weight of the fish in the various salinity treatments ranged from 5.4 to 6.2 g and were not statistically different. During the first 7 days post-stocking, 2 dead fish were replaced with similar-sized fish.

Recirculated water was injected through the perforated PVC pipes to provide a rotational movement to the culture water. Tank inflow rates averaged 30–35 liters/minute and new water was added to the system weekly to compensate for losses due to evaporation and splashing. Temperature was recorded daily and other water quality parameters consisting of pH, dissolved oxygen, ammonia, nitrite, and nitrate were monitored weekly. Salinity was monitored bi-weekly.

Fish were fed a 45% protein soft-moist pellet (Bio Products Inc., Warenton, Oregon) ad libitum 3–4 times daily (total daily amount ~5% body weight). Pellet size was increased on day 57 from 2.5 mm to 3.0 mm which was fed until completion of the study. At 3-week intervals during the 126-day study all fish were removed from the tanks, anesthetised with MS 222, counted, and individually weighed. The tanks were siphoned bi-weekly and scrubbed at each 3-week sampling. Filter beds were dismantled and cleaned following the fourth sample (day 84).

Homogeneity of variances was confirmed using the F-max test and ANOVA was employed to determine if statistical differences occurred among the various data sets. When ANOVA comparisons were statistically significant ($P \leqslant 0.05$), Duncan's Multiple Range Test ($P \leqslant 0.05$) was used to identify specific treatment differences. All survival data (%) were arcsin transformed before analysis.

Results

Water Quality

There were no major differences in water quality parameters among the various salinity treatments (Table 1). Mean temperature was 23.3° C and ammonia, nitrite,

Table 1. Mean water quality data recorded during study examining effects of six salinities on hybrids of striped bass × white bass.

Treatment salinity (ppt)	Water Quality Parameters						
	Salinity[a] (ppt)	Temp[b] (°C)	NH_4-N[c] (mg/l)	NO_3-N[d] (mg/l)	NO_2-N[e] (mg/l)	pH[f]	Oxygen[g] (mg/l)
0	1.0	23.2	1.02	13.81	0.24	7.2	7.3
7	7.3	23.3	1.08	14.62	0.19	7.3	7.2
14	14.1	23.3	<1.00	8.96	0.18	7.0	6.7
21	21.2	23.4	1.04	13.50	0.15	7.0	6.6
28	28.3	23.4	1.04	10.74	0.20	6.8	6.4
35	35.0	23.2	1.06	11.97	0.15	7.1	5.9

[a]Salinity measured with a temperature corrected American Optical Refractometer.
[b]Temperature measured with a stem mercury thermometer.
[c]NH_4-N measured with a Lamotte Chemical Co. colorimetric test kit model PAN.
[d]NO_3-N measured with a Lamotte Chemical Co. colorimetric test kit model ENA.
[e]NO_2-N measured with a Lamotte Chemical Co. colorimetric test kit model PLN.
[f]pH measured with a Lamotte Chemical Co. colorimetric test kit model P-5085.
[g]Oxygen measured with a Yellow Springs Instrument Co. Model 57 meter.

Table 2. Mean stocking and harvest data for hybrids of striped bass × white bass reared at 6 salinities for 126 days.

	Stocking data			Harvest data			
		Density					
Treatment salinity (ppt)	Fish wt. (g)	(N/m^3)	(kg/m^3)	Fish wt. (g)	Survival (%)	Biomass (kg/m^3)	Feed conversion[a]
0	6.0	185	1.12	68.7	86.7	10.8	1.48
7	5.7	185	1.06	63.7	96.7	11.4	1.67
14[b]	6.2	185	1.14	33.1[b]	100.0[b]	6.1[b]	2.48[b]
21	5.7	185	1.06	64.2	93.3	11.2	1.32
28	5.4	185	1.01	65.3	90.0	10.8	1.50
35	5.8	185	1.07	66.2	60.0	6.7	1.71

[a]Cumulative feed conversion data are through day 105. Data for last period were not available.
[b]All fish in salinity treatment 14 ppt died after sampling on day 105. Data presented are from day 105.

nitrate, and pH levels were generally similar. Mean dissolved oxygen levels decreased with increasing salinity and ranged from 7.3 (0 ppt) to 5.9 (35 ppt). Actual salinity levels varied little from the desired experimental salinities, however, treatment salinity 0 actually averaged 1 ppt (Table 1).

Growth

Mean fish size increased ≥11-fold in all salinity treatments, except 14 ppt, during the 126-day study (Table 2, Fig. 1). In general, growth was more or less similar among the various treatments although statistical analyses indicated differences in mean sizes among different treatments at various sample intervals (Table 3). However, no trends were consistent, and by the end of the study, no differences could be detected among final mean fish weights (Table 3). At conclusion, mean sizes among treatments ranged from 63.7 (7 ppt treatment) to 68.7 g (0 ppt treatment) and overall mean fish weight was 65.6 g.

Table 3. Summary of statistical analyses (Duncan's Multiple Range Test) for sample period 2 (6 weeks), 4 (16 weeks), and harvest (H-18 weeks) for hybrids of striped bass × white bass reared in different salinities. Data (salinity treatments) are ranked from highest to lowest values.

	Mean weight (g)			Survival (%)			Standing crop (kg/m^3)			Feed conversion		
Rank	2	4	H	2	4	H	2	4	H	2	4	H[a]
1	0A[b]	0A	0A	0A	0A	7A	0A	0A	7A	35A	14A	14A
2	28AB	28A	35A	7A	7A	21A	14AB	7AB	21A	14AB	35A	35B
3	14AB	7A	28A	14A	14A	28A	7AB	28AB	28A	28AB	7AB	7B
4	7AB	21A	21A	28A	21A	0A	28B	21B	0A	7AB	28AB	28B
5	21B	35A	7A	21A	28A	35B	21BC	14B	35B	21B	0B	0B
6	35B	14B		35B	35B		35C	35C		0B	21B	21B

[a]Cumulative feed conversion data at harvest were not available. Cumulative feed conversion data for sample 5 are presented.
[b]*All treatments followed by the same letter are not significantly ($P \leq 0.05$) different.*

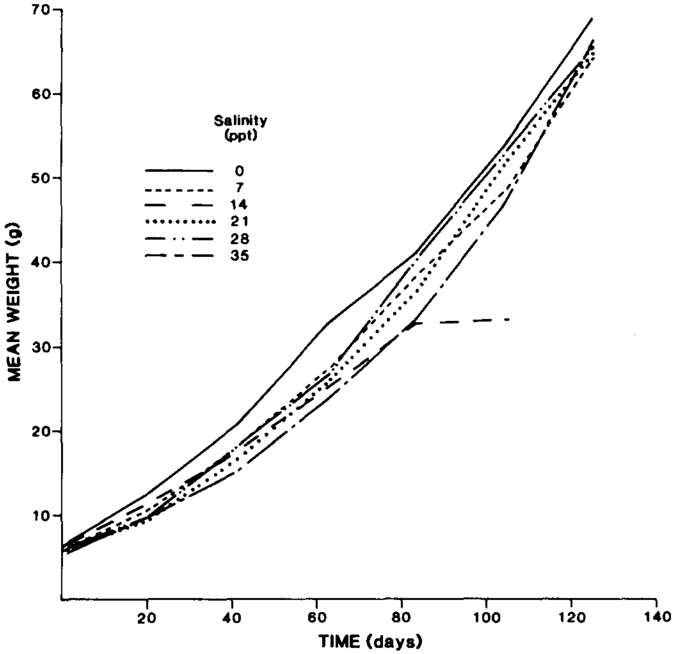

Figure 1. Growth of hybrids of striped bass x white bass reared at different salinities.

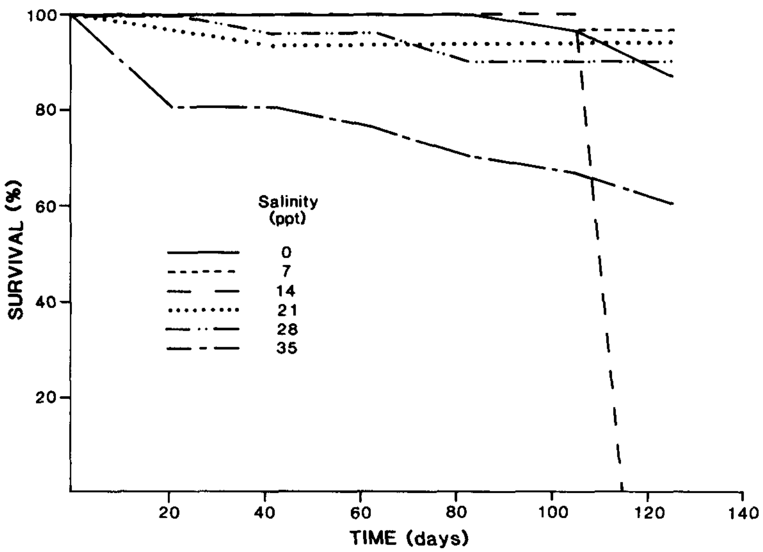

Figure 2. Survival of striped bass/white bass hybrids reared at different salinities.

Survival

Excluding the highest salinity treatment (35 ppt), survival was quite high and averaged 90.6% on day 105 (Fig. 2). Survival at salinity 14 ppt remained at 100% until after day 105 when all fish died within 3 days of sampling. Mortality in this treatment did not appear to be salinity related but rather it is believed to be the result of disease infection. During period 5 (day 84–105) fish size did not increase, even though fish continued to feed normally (Table 1). Mortality of fish reared at 35 ppt occurred early in the study and continued throughout the culture period. Statistical analyses of the survival data indicated that fish in all treatments except the highest salinity (35 ppt) survived similarly (Table 3). At conclusion of the study, mean survival for treatments 0, 7, 21, and 28 ppt was 91.7% while 60.0% was recorded for the 35 ppt treatment (Table 2).

Standing Crop

Biomass increased substantially in all salinity levels in spite of the relatively small size of the culture tanks. Statistical analyses indicated that there were detectable differences during the various sample periods (Table 3). However, such differences changed with time and no trends were apparent except for the 35 ppt treatment which consistently had the lowest biomass throughout most of the study. At conclusion of the study, mean standing crop was 11.1 kg/m^3 for treatments 0, 7, 21, and 28 ppt and 6.7 kg/m^3 for treatment 35 ppt.

Feed Utilization

Feed conversions recorded during the study averaged 1.7 and ranged from 1.3 to 2.5 (Table 2). In general, most feed conversions were statistically similar (Table 3). With the exception of salinity 14 ppt, no differences could be detected among the overall cumulative feed conversions obtained at the various salinity treatments.

Discussion

Results of this study demonstrate the ability of hybrids of striped bass x white bass to survive and grow in a broad range of salinities. Growth and survival rates were similar in salinities to 28 ppt but at a salinity of 35 ppt survival was somewhat depressed. Growth at 35 ppt was statistically similar to that recorded in all other salinities but the reduced population density at 35 ppt may have allowed a more rapid growth rate than that which would have occurred if population density was as high as that in the lower salinity treatments.

As reported previously, hybrid bass will readily accept and grow on pelleted rations. Except for the 14 ppt salinity treatment, feed conversions obtained in this study ranged from 1.3 to 1.7 and no overall differences in feed utilization were detected. For comparison, feed conversions of 1.94 (Collins et al. 1984), 1.3 (Carlberg et al. 1984), and 2.21 (Smith et al. 1985) have been obtained in culture trials with these hybrids or the reciprocal hybrids. In spite of the small size of the culture tanks, relatively high standing crops were achieved (≤11.4 kg/m³). Final standing crops were similar at salinities of 0-28 ppt (range 10.8 to 11.4 kg/m³) and lower (6.7 kg/m³) at the highest salinity (35 ppt) which had the poorest survival (60%) of all treatments. In an earlier 302-day study using recirculated brackish water (4.9 ppt), Smith et al. (1985) demonstrated a production level of 43.1 kg/m³ with these hybrids when reared in a 1.8 × 0.7 m deep tank.

In summary, this study indicated that hybrids of striped bass x white bass are euryhaline and can grow in even oceanic salinities (35 ppt). Thus, inland as well as coastal sites will be suitable for development of aquaculture operations. From a management perspective, possible long term effects of these euryhaline hybrids on native species needs to be considered in the formulation of stocking programs for coastal and estuarine areas.

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