GROWTH AND SURVIVAL OF STRIPED BASS AND STRIPED BASS X WHITE PERCH HYBRIDS

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Abstract: Experiments comparing growth and survival of striped bass (*Morone saxatilis*) and striped bass♀ X white perch (*M. americana*)♂ hybrids indicated the hybrids were hardier than striped bass under the same experimental conditions. Striped bass exhibited health problems and resulting mortality which were not evident in the hybrids. Overall survival of striped bass in 2 replicate experiments was 42.5% after 11 months, whereas that of the hybrids was 84.2%. Striped bass and hybrid growth patterns were similar, but striped bass grew somewhat more rapidly than the latter. Mean specific (instantaneous) growth rates were roughly similar throughout the study, with the major differences occurring during the first 4 months. At 17 months of age the mean hybrid fork length was 227.5 mm (range, 167 to 282 mm). This length was approximately equivalent to that of wild populations of white perch with 4 to 8 annuli and to that of mid-Atlantic striped bass with 2 annuli, but was substantially less than that of fresh-water and more southern populations. Hybrid length-weight equations were intermediate between those of striped bass and white perch. Salinity experiments demonstrated that both small (mean fork length, 43 mm) and large (mean fork length, 279 mm) hybrids can survive and grow for indefinite periods at salinities of 18 to 25 o/oo with no signs of stress. We believe that the hybrid may be suitable as a supplement to natural populations of striped bass and white perch in estuaries.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32: 715-726

Striped bass X white bass (*M. chrysops*) hybrids have been artificially propagated and stocked in fresh-water impoundments as a management tool and a food and sport fish since 1965. They are hardier, more adaptable, and have more rapid early growth rates than striped bass. In addition, they are particularly well suited for areas where striped bass cannot reproduce (Bishop 1968; Williams 1971; Bonn et al. 1976). Although the hybrids are fertile, they apparently do not reproduce under natural conditions (Bayless 1972).

Because of the success of the striped bass X white bass hybrids, we decided to investigate the potential of the striped bass♀ X white perch♂ hybrid. We thought that the hybrid might remain in an estuarine environment, as does the white perch, rather than undergo the extensive migrations of the striped bass. The potential of increased growth of a resident species could enhance both recreational and commercial fisheries, particularly during those periods when commercially valuable striped bass are largely absent from the estuaries. In the present study, we compared growth rates, survival, and length-weight relationships of striped bass and striped bass X white perch hybrids under the same experimental conditions. Hybrid growth was also compared to growth of natural populations of striped bass and white perch. In addition hybrid salinity tolerance was examined.

Financial support was provided by Sea Grant funds from the National Science Foundation under P.L. 89-688 (Project Nos. GH-37 and GH-67) and the National

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Oceanic and Atmospheric Administration (Project Nos. 1-36032 and NG-S-72). We thank J. D. Bayless for use of the facilities at the South Carolina striped bass hatchery and for assistance in making the crosses; J. Loesch for assistance with statistical procedures; R. W. Moncure for computer programs; and R. G. Burbidge, D. R. Calder, G. A. Marsh and J. E. Weaver for assistance in the laboratory. M. T. Huish, J. Loesch, and C. E. Richards reviewed earlier drafts of the manuscript. B. Kerby typed the manuscript. This is Contribution No. 914 from the Virginia Institute of Marine Science.

MATERIALS AND METHODS

Eggs from a female striped bass were fertilized with sperm from 4 white perch (taken from the Rappahannock River, Virginia) at the Moncks Corner (South Carolina) Striped Bass Hatchery. Eggs from the same female were also fertilized with striped bss sperm. After the eggs hatched, the larvae were transported to the Virginia Institute of Marine Science. They were fed newly hatched brine shrimp (*Artemia* sp.) 4 times daily until they were approximately 30 mm in total length. They were then conditioned to eat Purina Trout Chow[a], a dry commercial mix containing not less than 40% protein.

Striped bass for the growth experiments were seined from the James River, Virginia, held in running fresh water, and conditioned to eat the dry food. Use of wild fish was necessary because of complete mortality of cultured striped bass.

Two 1,300 fiberglass tanks (305 cm long x 76 cm wide x 56 cm high) were partitioned lengthwise with polyethylene screening to provide 2 identical compartments. Each compartment was further divided into 3 smaller chambers of equal size (91 cm long x 30 cm wide). Screens placed 16 cm from each end of the tank separated the end chambers from incoming and outflowing water (Fig. 1). Well water was introduced at the rate of about 230 l/h, so that a complete water exchange occurred 4 times daily. Each chamber was aerated vigorously through airstones. Temperature was maintained near 24 C by passing inflowing water through a thermostatically controlled heat exchanger.

Two replicate experiments were conducted. Fish were assigned to alternating chambers in experiment 1 as follows: A = striped bass, B = hybrids, C = striped bass, D = hybrids, E = striped bass, F = hybrids (Fig. 1). The arrangement was reversed in experiment 2. Each chamber contained 20 fish resulting in a total of 60 striped bass and 60 hybrids per tank. The fish were selected for size uniformity to help eliminate individual competitive advantages due to initial size. They were weighed to the nearest 0.1 g and measured to the nearest millimeter (fork length) at approximately 30 day intervals for 11 months, beginning in September 1970. At the end of each period, individual fish were anesthesized in a 20 mg/l solution of quinaldine, measured, blotted with absorbent paper, weighed in a known weight of water, and returned to their respective tanks. They were not fed for 24 hours prior to weighing to allow food material to be evacuated.

The fish were fed twice daily with more food than they would consume. It was assumed that the food provided equal nutrition for both striped bass and hybrids.

Mean specific (instantaneous) growth rates, estimated as percentage increase in length and weight per day, were calculated at the end of each growth period with the formula,

$$G = \frac{\log_e Y_t - \log_e Y_0 \times 100}{t}$$

where G = specific growth rate,

Y_t = length or weight at the end of the period,

Y_0 = length or weight at the beginning of the period, and

t = time in days.

[a]Reference to trade name does not imply endorsement of commercial products.

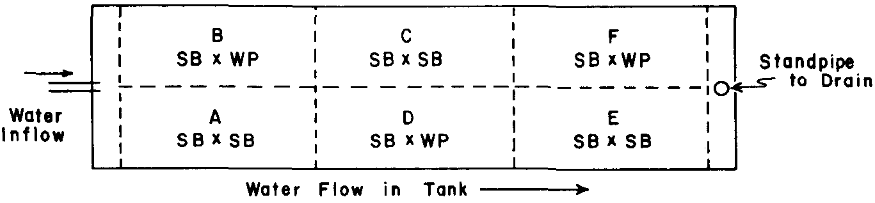

Fig. 1. Diagram of experimental tanks used in growth studies (SB = striped bass; WP = white perch).

The calculation of G, which accounts for both initial and final sizes, is useful in comparing growth of fish of different sizes (Brown 1957).

Length-weight relationships were calculated by the method of least squares for 1131 experimental striped bass, 1385 hybrids, 1364 wild striped bass obtained from the Rappahannock River, Virginia, and 775 white perch obtained from the York River, Virginia. Data for the experimental fish consisted of repeated measurements, through time, of the same individuals in the 2 growth experiments. Analysis of covariance was used to test for significant differences at the 0.05 probability level.

We conducted 2 salinity experiments to determine whether the hybrids could tolerate continuous exposure to salinities above 15 o/oo. In the first experiment, 10 small individuals (mean fork length, 43.3 mm; range, 41 to 46 mm) were placed in a 19-liter aquarium containing fresh water. They were acclimated by increasing the salinity about 1 o/oo daily until it was about 25 o/oo. In the second experiment, 30 large fish (mean length, 279 mm, range, 241 to 317 mm) were held in a 1,300 l fiberglass tank and acclimated to a salinity of ca. 18 o/oo over a period of a week and then maintained in a continuous flow of filtered York River water. Salinities were monitored daily with a hydrometer.

RESULTS AND DISCUSSION

Growth and Survival

The hybrids were hardier than striped bass under experimental conditions. After the fourth growth period some striped bass weighed less than was expected for fish of their lengths, and appeared slightly emaciated. During later periods these fish became more emaciated and others began to exhibit the condition. These individuals continued to feed, but grew at reduced rates and eventually died. In the terminal stages growth in length ceased and loss of weight occurred. Mortality increased radically during the latter part of the study. Only 51 of 120 striped bass (42.5%) survived in the 2 experiments. None of the hybrids became emaciated, although a few appeared thinner than would be expected for their length. Survival of hybrids was 84.2%, almost twice that of striped bass (Tables 1 and 2). All remaining hybrids in the 2 experiments appeared to be in good health, but several of the surviving striped bass were emaciated and eventually died. Most hybrid mortality was attributed to fungal infections which probably resulted from handling procedures.

Growth curves from the 2 experiments were similar except that in experiment 1 hybrid mean weights were never greater than those of striped bass, whereas in experiment 2 they exceeded those of striped bass at the end of the third period and remained greater throughout the remainder of the study (Figs. 2 and 3). Mean weights of striped bass during growth periods which included significant mortalities of emaciated fish were inflated by the healthier, heavier individuals that remained.

Table 1. Growth and survival of striped bass and striped bass X white perch hybrids, experiment 1.

	Striped Bass						Hybrids					
Days Elapsed	N	Mean Fork Length (mm)	Mean Growth in Length Per Day (mm)	Mean Weight (g)	Mean Growth in Weight Per Day (g)	Survival (%)	N	Mean Fork Length (mm)	Mean Growth in Length Per Day (mm)	Mean Weight (g)	Mean Growth in Weight Per Day (g)	Survival (%)
0	60	62.8	---	3.0	---	---	60	62.7	---	3.3	---	---
32	60	90.2	0.86	10.0	0.22	100.0	60	80.1	0.54	7.1	0.12	100.0
62	60	106.6	0.55	16.4	0.21	100.0	60	96.5	0.54	12.5	0.18	100.0
92	58	121.5	0.50	24.1	0.26	96.7	60	112.7	0.54	20.1	0.25	98.3
122	54	135.8	0.48	33.8	0.32	90.0	59	127.8	0.50	30.2	0.34	98.3
152	53	150.9	0.50	45.8	0.40	88.3	59	141.7	0.46	42.2	0.40	98.3
182	51	169.9	0.63	66.0	0.67	85.0	59	157.8	0.54	59.4	0.57	98.3
212	37	187.4	0.58	88.5	0.75	61.7	59	173.6	0.53	80.7	0.71	98.3
242	35	208.8	0.71	120.6	1.07	58.3	59	191.6	0.60	108.0	0.91	98.3
272	34	225.1	0.54	149.3	0.96	56.7	59	202.5	0.37	127.4	0.65	98.3
302	29	237.8	0.42	175.9	0.89	48.3	54	211.5	0.30	150.5	0.77	90.0
332	28	262.7	0.50	203.4	0.92	46.6	49	222.8	0.38	171.1	0.69	81.7

Table 2. Growth and survival of striped bass and striped bass X white perch hybrids, experiment 2.

	Striped Bass						Hybrids					
Days Elapsed	N	Mean Fork Length (mm)	Mean Growth in Length Per Day (mm)	Mean Weight (g)	Mean Growth in Weight Per Day (g)	Survival (%)	N	Mean Fork Length (mm)	Mean Growth in Length Per Day (mm)	Mean Weight (g)	Mean Growth in Weight Per Day (g)	Survival (%)
0	60	73.8	---	5.3	---	---	60	73.5	---	5.6	---	---
31	60	98.1	0.78	12.7	0.24	100.0	60	90.1	0.54	10.4	0.16	100.0
61	59	115.2	0.57	21.2	0.28	98.3	60	106.7	0.55	17.8	0.25	100.0
91	58	126.5	0.38	25.9	0.16	96.7	59	121.8	0.50	26.5	0.29	98.3
121	53	140.5	0.47	35.9	0.33	88.3	59	136.2	0.48	38.2	0.39	98.3
151	50	159.5	0.63	52.7	0.56	83.3	58	152.9	0.56	55.6	0.58	96.7
181	49	180.5	0.70	72.2	0.65	81.7	58	172.3	0.65	77.2	0.72	96.7
211	45	201.3	0.70	99.4	0.91	75.0	58	191.5	0.64	109.4	1.07	96.7
241	43	215.4	0.47	121.5	0.74	71.7	56	205.2	0.46	132.4	0.77	93.3
271	42	226.1	0.36	139.1	0.59	70.0	55	214.6	0.31	146.7	0.48	91.7
301	30	237.2	0.37	156.1	0.56	50.0	53	222.8	0.27	168.9	0.74	88.3
331	23	246.1	0.30	174.3	0.61	38.3	52	231.8	0.30	195.9	0.90	86.7

Generally, striped bass growth was considerably greater than hybrid growth during the first month, but slowed relative to that of the hybrids during subsequent periods. Differences between the 2 forms were reduced to some extent in later months (Figs. 2 and 3).

Mean specific growth rates were greatest for both striped bass and hybrids at the end of the first growth period, and generally tended to decrease thereafter (Figs. 4 and 5). The high initial values probably resulted, at least in part, from the favorable reduction in density and competition that accompanied transfer from holding to experimental conditions. A similar growth "surge" was reported by Brett et al. (1969) in experiments with sockeye salmon (*Oncorhynchus nerka*). Specific growth rates of striped bass and hybrids were roughly similar throughout the study, with the greatest differences occurring during the first 4 months (Figs. 4 and 5). Rates varied considerably from month

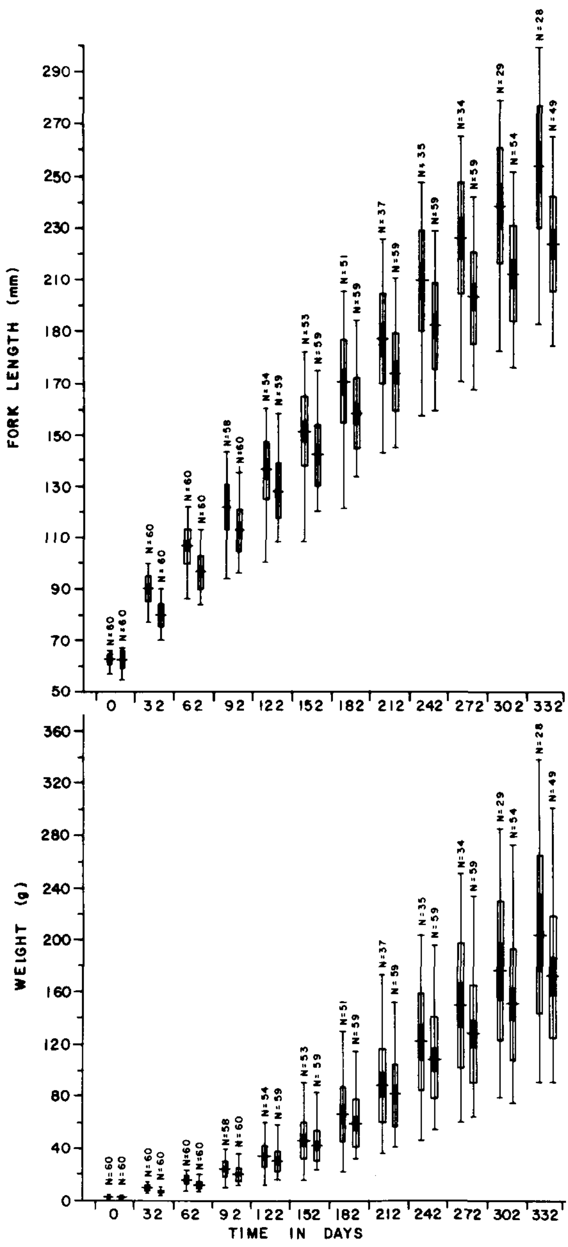

Fig. 2. Growth statistics of striped bass and striped bass X white perch from experiment 1. Striped bass statistics are plotted as the left member of each pair. Centered vertical line = range; centered horizontal line = mean; open bar = one standard deviation to either side of mean; shaded bar = confidence interval (x ± s-t.05). x

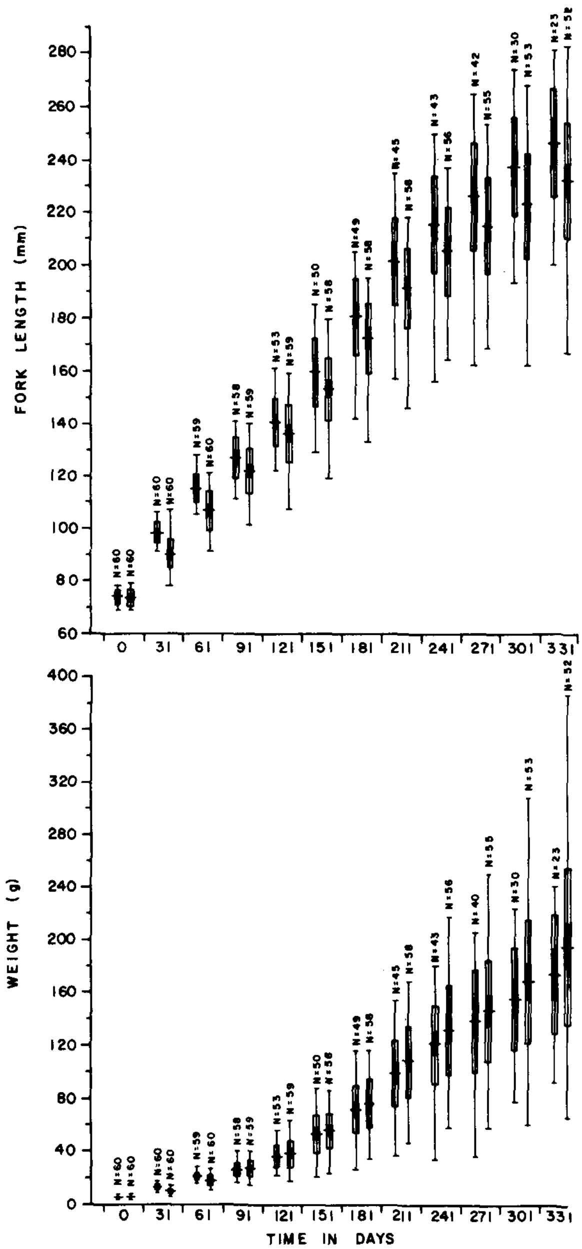

Fig. 3. Growth statistics of striped bass and striped bass X white perch from experiment 2. Striped bass statistics are plotted as the left member of each pair. See Figure 2 for explanation of symbols.

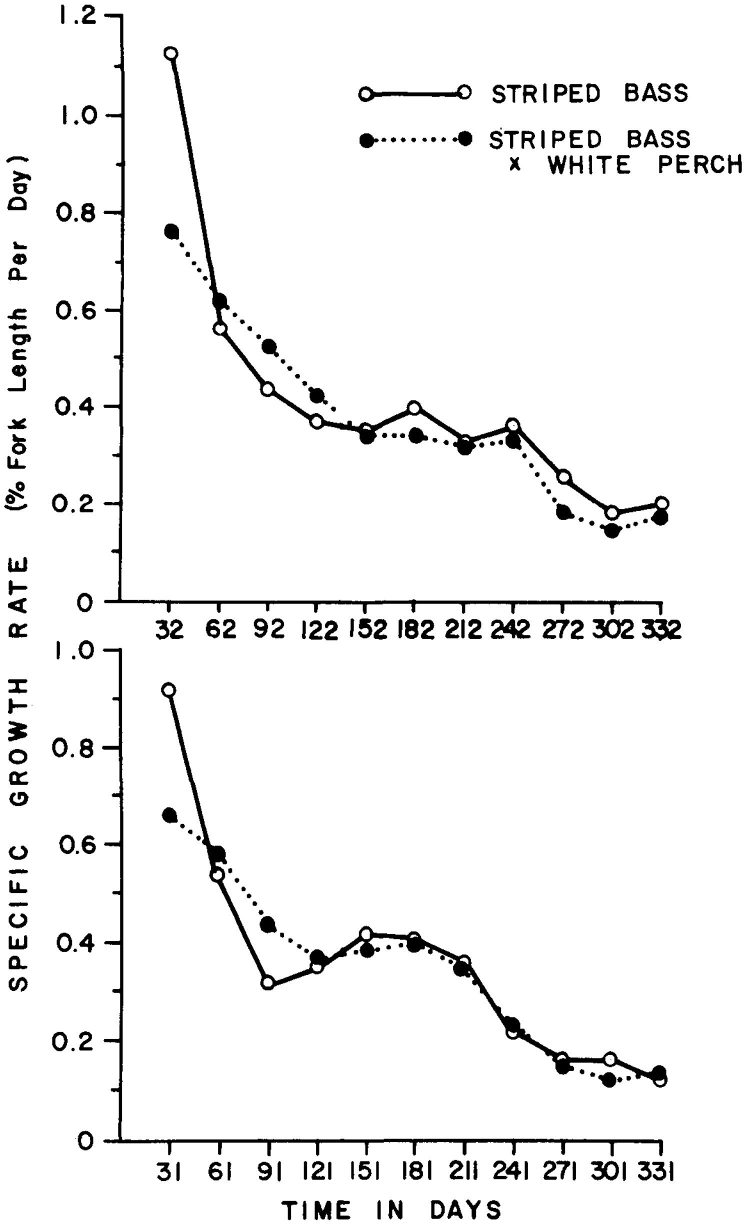

Fig. 4. Mean specific growth rates for striped bass and striped bass X white perch, estimated as percentage increase in length per day. Experiment 1 above; experiment 2 below.

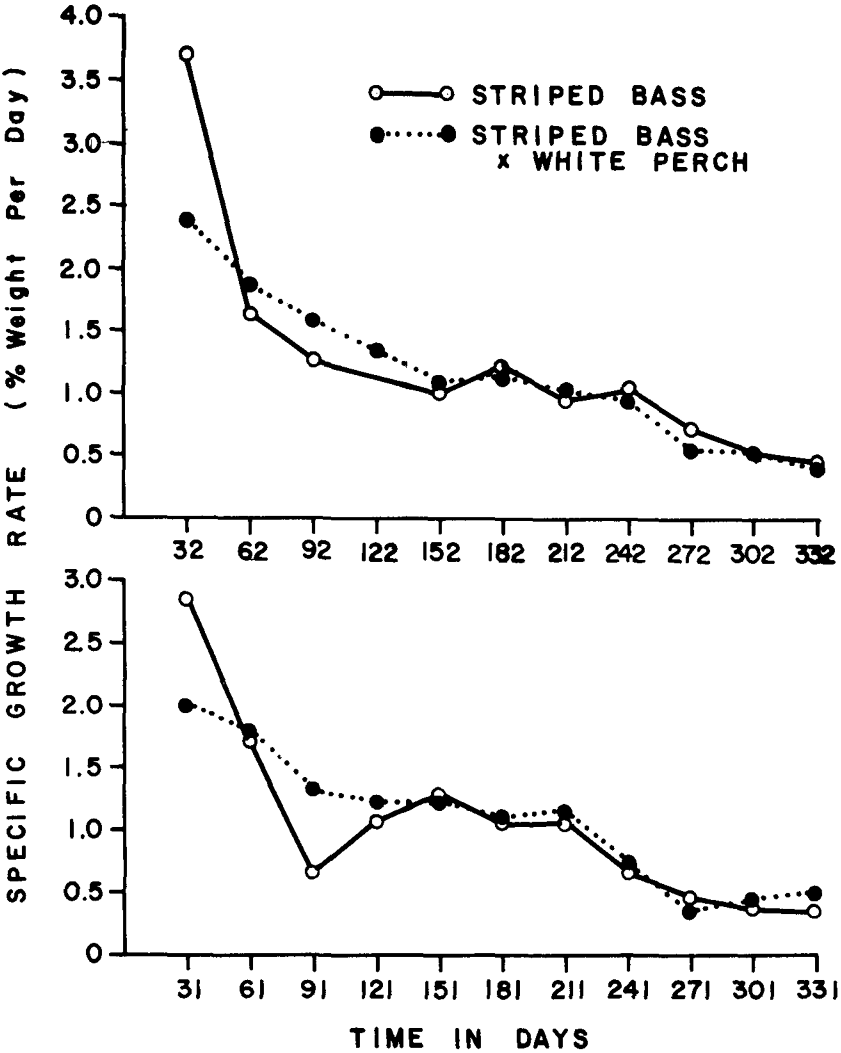

Fig. 5. Mean specific growth rates for striped bass and striped bass X white perch, estimated as percentage increase in weight per day. Experiment 1 above; experiment 2 below.

to month, generally decreasing during the fall and winter months, increasing during the spring months, and then decreasing during the summer months. Similar results were reported for brown trout (*Salmo trutta*) by Brown (1946), who observed a yearly cycle with a low specific rate in the autumn, rising through the winter to a maximum in early spring, followed by a gradual decrease during summer to a "check" in autumn. She believed that these changes represented inherent physiological changes in the fish rather than external factors because all external physico-chemical factors were rigidly controlled, including a constant temperature of 11.5 C and 12 hours of light and 12 hours of dark daily. Similar seasonal variations in growth rates were also observed in brown trout by Swift (1955) and in sockeye salmon by Brett et al. (1969).

Growth Comparisons Between Hybrids and Parental Species

At 17 months of age, the mean length of the 101 remaining hybrids was 227.5 mm (range, 167 to 282 mm). This length, when compared with back-calculated lengths of white perch in natural populations, was approximately equal to that of 7 year olds in the Patuxent River, Maryland (Mansueti 1961a); 7 or 8 year olds in the James and York Rivers, Virginia (St. Pierre and Davis 1972); 6 year olds in the Roanoke River, North Carolina (Conover 1958); and 4 year olds in a recently established Lake Erie population (Busch et al. 1977). Mean length of 8 year old fish in the Delaware River was 206.6 mm (Wallace 1971).

The mean length of the hybrids was slightly less than reported back-calculated means for 2 year old striped bass along the mid-Atlantic coast, which ranged from 235 to 356 mm (Merriman 1941; Mansueti 1961b; Trent and Hassler 1968; Kerby 1972). Reports of striped bass in fresh-water streams and reservoirs indicated that they grew much faster than did the hybrids in the laboratory. Two year old striped bass were 371 mm long in the Santee-Cooper Reservoir, South Carolina (Stevens 1958) and 323 mm long in the Choctawatchee River, Florida (Wigfall and Barkuloo 1976). Striped bass with one annulus were 262 mm long in Florida lakes (Ware 1971) and in Keystone Reservoir, Oklahoma (Erikson et al. 1972).

Length-Weight Relationship

Covariance analysis revealed that regression coefficients for the experimental striped bass and hybrids were significantly different ($F = 357.2$; $df = 1, 2{,}512$), with data from hybrids producing the greater slope (Fig. 6). Because of striped bass emaciation during the later stages of the experiments, a regression equation was calculated for wild striped bass of a similar size range. The slopes of the 2 equations for striped bass differed significantly ($F = 15.9$; $df = 1, 2{,}491$), with the regression for the wild fish having the greater slope (Fig. 6). The white perch length-weight equation had a slope greater than that of the hybrid. Thus, hybrids increased in weight at a more rapid rate per unit length than did striped bass, but at a less rapid rate than did white perch (Fig. 6).

Salinity Tolerance

Hybrids acclimated to 25 o/oo salinity were held for 173 days without mortalities. They fed actively, showed no signs of stress and continued to grow. At the end of the experiment, mean fork length was 100.1 mm, an increase of 56.8 mm. Hybrids acclimated to ca. 18 o/oo in the flow-through system and maintained in the system for 156 days also continued to feed actively and showed no signs of stress. Salinities fluctuated daily, but generally remained between 17 and 19 o/oo (range, 14.6 to 19.8 o/oo). Mean length for the 28 fish at the end of the experiment was 290.2 mm, an increase of 11.2 mm.

Feasibility of Introduction into Estuaries

Because experimental evidence suggests that the striped bass X white perch hybrid will grow much faster and to a larger size than resident white perch, it is potentially valuable to both sport and commercial fishermen during the summer, when most of the larger striped bass leave the estuaries on their annual migrations. We have demonstrated that the hybrid is capable of living in salinities up to 25 o/oo. Whether or not it would naturally move into salinities as high or higher than this is not known. If it can be demonstrated that salinity will serve as a natural barrier, the hybrid might be suitable for use as a supplement to natural populations of striped bass and white perch.

An objection to stocking the hybrid in an estuary arises from the possibility that back-crossing with striped bass or white perch might result in adverse effects on the gene

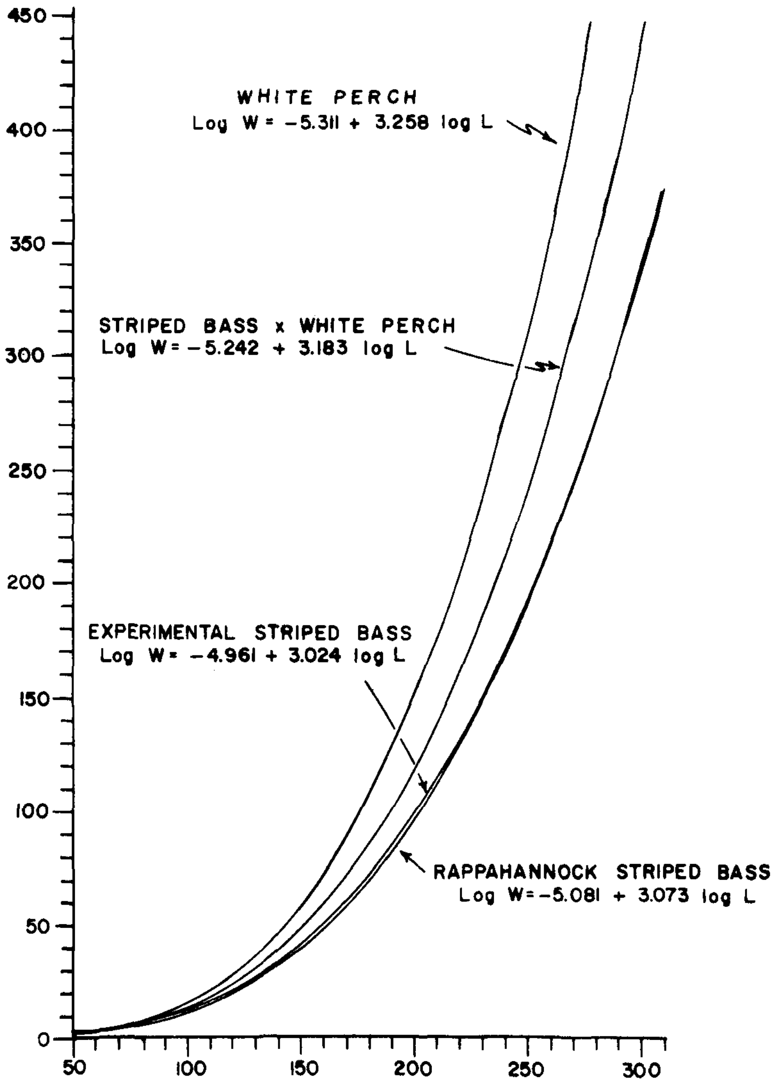

Fig. 6. Calculated length-weight curves for experimental striped bass and striped bass X white perch, wild striped bass and wild white perch. In the equations, W = weight in grams and L = fork length in millimeters. Coefficient of determination r^2 was 0.98 for each equation.

pools of these species. However, no evidence has been obtained to demonstrate the occurrence of back-crossing between striped bass X white bass hybrids and striped bass or white bass (Bayless 1972). Even if occasional hybrid reproduction or back-crossing did occur, it probably would not affect the gene pools of the parental species. The sheer numbers involved in reproduction of the parent species would most likely result in rapid extinction of foreign genetic characteristics.

A second, and perhaps more valid, consideration concerns the possible effects of competition between the hybrids and striped bass and white perch in the estuary. Striped bass, white bass and their hybrid currently coexist in several southeastern reservoirs without apparent harm to the parent populations. Additionally, the relative numbers of striped bass and white perch present in estuarine populations would be much greater than those of the hybrids. Because of these factors, we believe that competition, at least in experimental stockings, would not damage either striped bass or white perch populations. Nevertheless, such experiments should be closely monitored to determine whether the hybrids reproduce and compete with parent stocks.

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