FISHERIES SESSION

EVALUATION OF THE STRIPED BASS X WHITE BASS HYBRID FOR CONTROLLING STUNTED BLUEGILLS

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Abstract: We studied fish populations in four lakes in southwestern Oklahoma before and after stocking striped bass *(Morone saxatilis)* × white bass *(M. chrysops)* hybrids to determine if the population structure changed as a result of predation by the hybrids. Two lakes were stocked with hybrid fingerlings at 45 fish/ha in fall 1979 and again with fry at 120 fish/ha in spring 1980. The other two lakes (the controls) were not stocked. Although growth of hybrid fingerlings was good, survival was poor. Mortality was greatest for fingerlings less than 150 mm in total length at the time of stocking. None of the fry stocked was recovered. Based on the distribution of hybrids and their food, it appeared that they utilized primarily the limnetic zone and did not feed extensively on centrarchids. Changes in the "apparent" structure of populations of bluegill *(Lepomis macrochirus)* were not consistent and could not be attributed to predation by hybrids.

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One of the major problems of managing small impoundments is that of maintaining a balanced fish population, which Swingle (1950) defined as one capable of producing a satisfactory sustained yield to sport fishing. He recognized the importance of predation in structuring the prey population and believed that balanced populations must contain more than 1 species and must include a piscivorous species. The maintenance of balanced fish population is particularly difficult when intense angling pressure is directed at the piscivorous species; stunting of the prey species then often occurs (Powell 1975). The problem of stunted panfish populations is widespread and has long been recognized for many species (Beckman 1941, Burris 1956, Regier 1963). A recent survey of small state owned impoundments in Oklahoma indicated that the fish populations of many are dominated by stunted sunfish, primarily bluegill (personal communication C. Wallace).

Stunted populations are generally characterized by large numbers of slow growing fish, often in poor condition. Since stunted populations are characterized by high density, many attempts have been make to reduce populations by partial

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poisoning, intensive netting, electricity, or stocking of predators (Grice 1958, Jenkins 1959, Houser and Grinstead 1962, Hackney 1966, Spencer 1967). Generally, reduction in population size (by up to 60%) by mechanical or chemical methods resulted in either no significant change in the remaining fish population (Houser and Grinstead 1962, Graham 1974) or in only temporary improvements in growth (Beckman 1950, Cooper et al. 1971).

Stunted populations are symptomatic. Although growth rates of bluegill are density dependent (Buck and Thoits 1970, Elrod 1971), beneficial effects resulting from a reduction in population density by mechanical or chemical means were quickly offset by reproduction. Swingle and Smith (1942) concluded that predation was the only feasible mechanism regulating density of bluegills. More recently, Anderson (1973, 1976) reemphasized the importance of piscivorous fish for maintaining a suitable size structure in the prey population. However, predation may be limited by an overharvest of piscivorous species such as largemouth bass *(Micropterus salmoides)* (Bonneau and Conley 1974, Redmond 1974). Predation pressure may also be low because of limited recruitment or restrictive habitat requirements of the predator, or because the vulnerability of prey differs in different habitats. In all of these situations, one of the options available to the fish manager is the introduction of an exotic predator that, because of its behavior, morphology, or physiology, may be more effective than endemic species in controlling prey populations. One such exotic predator that has potential to alter the structure of stunted sunfish populations is the hybrid of the striped bass × white bass.

The striped bass × white bass hybrid was first produced in South Carolina in 1965 (Logan 1968). Since then, this hybrid has been widely stocked throughout the southeastern and southcentral United States, primarily into large reservoirs to feed on threadfin shad *(Dorosoma petenense)* and gizzard shad *(D. cepedianum)* (Williams 1971, Ware 1975). However, hybrids maintained in hatcheries readily accepted a variety of prey species, including bluegill (Bishop 1968). Because of their high survival, fast growth rate, and ability to feed on sunfishes, we hypothesized that hybrids might exert sufficient predation pressure to favorably modify stunted sunfish populations.

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METHODS

This study was conducted on 4 lakes (small reservoirs) on the Wichita Mountains National Wildlife Refuge near Lawton, in southwestern Oklahoma. The rufuge consists of 24,590 ha of land with rolling prairies, narrow and wooded intermittent and perennial water courses, and rough rocky hills. The numerous impoundments on the refuge range in size from 1 to 225 ha; all were constructed in the 1930's. After preliminary sampling, 4 lakes were selected for our study (Table 1). These lakes are relatively clear, and consequently support dense stands of aquatic macrophytes, which occur throughout the littoral zone except in areas with rocky substrates. The lakes become strongly stratified by early June and are

Table 1. Characteristics of 4 study lakes on the Wichita Mountains National Wildlife Refuge. Caddo and Jed Johnson lakes were stocked with striped bass × white bass hybrids; Crater and Rush lakes were the controls.

Lake[a]	Surface area (ha)	Mean depth (m)	Secchi disc reading (m)	Dissolved oxygen at 2 m (mg/1)
Caddo	4.6	3.0	2.4	2.5
Crater	3.8	1.8	0.9	2.2
Jed Johnson	31.0	5.6	1.5	9.0
Rush	20.9	4.8	1.4	8.9

[a] Dominant vegetation was *Elodea* in Caddo Lake; *Chara* and *Nelumbo* in Crater Lake; and *Myriophyllum, Eleocharis,* and *Chara* in Jed Johnson and Rush lakes.

axonomic below the thermocline. During summer, water temperatures generally range from 27 to 30 C at the surface and from 20 and 28 C in the thermocline. Fish populations are dominated by numerous species of centrarchids.

Our experimental design consisted of studing the structure of fish populations in 4 lakes for 1 season before stocking and 2 seasons after stocking. All lakes were sampled in the same way.

In November 1979, we stocked fingerling striped bass × white bass hybrids (average total length, 159 mm) into lakes Jed Johnson and Caddo at the rate of 45 and 47 fish/ha, respectively. Water temprature at the time of stocking was 12 C in both the lake and truck tank. In May 1980, we stocked hybrid fry into the same 2 lakes at 120 fish/ha. Lakes Crater and Rush served as "control" lakes and were not stocked with hybrids. These 2 lakes were continually monitored for any natural changes in the fish populations or gear efficiency.

Between April and June of each year, beginning in 1979, fish populations in the 4 study lakes were sampled principally with 2 kinds of nets (mesh is given in bar measure): barrel nets (0.9 m in diameter, 1.8 m long, with 1.9-cm mesh), and frame nets (0.9-m × 1.8-m entrance frame, 4.9 m long, and 1. 3-cm mesh, with a 15-m lead). Nets were generally set perpendicular to the shoreline in the littoral zone and moved about the lake daily.We used a 240-V, AC, 3,000-W generator mounted in a 5-m flat bottom boat for electrofishing in both spring and fall (October) each year. Total length of all fish was determined to the nearest millimeter and a representative sample of each species was weighed to the nearest gram; the fish were then released. All electrofishing was done after dark and we electrofished along the entire perimeter of a lake on each evening.

In lakes Jed Johnson and Rush, 2 seining sites (23 - 30 m long) in each lake were cleared of aquatic plants and large rocks, and the boundaries of each site were marked. In each lake, 1 site was seined once every 2 weeks and the other site was seined on 2 consecutive evenings every 2 weeks, from July to September. On each evening, we made a single haul parallel to shore within the site boundaries with a seine (6.4 m × 1.2 m; 6.4-mm sq mesh), all fish caught were preserved in 10% formalin for later measurement and identification.

Beginning in March 1980 we set experimental gill nets (46 m × 1.8 m, with 6 equal panels of the following mesh sizes (centimeters, bar measure: 1.9, 2.5, 3.8, 4.4, 5.1, and 6.4) on the bottom at various depths and also near the surface by attaching plastic jugs. We fished the floating gill nets either in groups of 3 nets forming a U-shape with 2 gasoline lanterns floated in the middle of the "U-shape," or alone and without lanterns. Since few other fish were collected, we measured, weighed, and removed the stomachs of only the striped bass × white bass hybrids collected in the gill nets. Cellulose acetate impressions were made of the scales. Stomachs were preserved in 10% formalin for later identification of contents to the lowest taxon practical. Non-parametric statistical tests followed Conover (1971).

RESULTS

Only the floating gill nets set in the limnetic zone successfully collected hybrids. Catch of hybrids per unit of effort was identical (0.1 fish/net) in gill nets set in conjunction with lanterns and those set alone. Scale analysis indicated that the 8 hybrids collected were from the original (1979) stocking of fingerlings (Table 2). Since the fingerlings were stocked in November, we assumed that little or no growth occurred before annulus formation the following spring, and that length at annulus formation closely approximated length at stocking. Back-calculation of length at annulus formation indicated that all hybrids collected were longer than 150 mm at time of stocking (Table 2). Survival was apparently low for shorter fingerlings, since 40% of the fingerlings were less than 150 mm long at the time of stocking. Although we sampled Caddo Lake monthly, we collected only 2 hybrids. Since no hybrids were collected there after June 1980, we believe that very few hybrids survived; consequently, data from Caddo Lake and its control, Crater Lake, are not further considered here.

Table 2. Length, weight, condition, and growth of striped bass × white bass hybrids collected from Caddo and Jed Johnson lakes.

Lake	collected	Total length (mm)	Weight (g)	Condition (K)	Length at annulus formation (mm)	Growth increment (mm)
Caddo	May 80	210	105	1.13	210	0
Jed Johnson	May 80	220	108	1.01	220	0
Caddo	June 80	225	134	1.18	202	22
Jed Johnson	July 80	260	233	1.27	173	87
Jed Johnson	July 80	260	226	1.29	157	103
Jed Johnson	Aug. 80	306	315	1.10	153	153
Jed Johnson	Sept. 80	332	398	1.09	170	162
Jed Johnson	April 81	362	570	1.20	190	172

Annulus formation occurred near the end of May, and most growth occurred between May and September. During the 1980 growing season, hybrids doubled in total length and increased their weight by an order of magnitude. All prey items found in hybrid stomachs occurred primarily in either the limnetic zone or in both the littoral and limnetic zones of Lake Jed Johnson (Table 3; unpulbished data). Brook silversides *(Labidesthes sicculus)* and adult mayflies *(Hexagenia* sp.) accounted for 46% of the food by weight, while gizzard shad larvae were numerically the most abundant food item.

Table 3. Stomach contents of 6 striped bass × white bass hybrids collected from lake Jed Johnson.

Food item	Number	Frequency of occurrence (%)	Weight (g)	% Total weight
Brook silversides	3	33	0.5544	26.0
Gizzard shad larvae	56	17	0.1710	8.0
Lepomis sp. larvae	13	17	0.0214	1.0
Unidentified fish	3	50	0.9250	43.3
Hexagenia adults	6	17	0.4252	19.9
Chironomid pupae	17	33	0.0380	1.8
Chironomid larvae	1	17	0.0010	0.1

In lakes Rush and Jed Johnson, bluegills were usually the most abundant species collected by electrofishing in both spring and fall (Tables 4, 5). Catch per unit of effort (c/f) for bluegills by electrofishing fluctuated considerably, both between seasons within years and within seasons between years. Further, these fluctuations were not consistent between the 2 lakes. For instance, c/f for bluegills steadily declined between consecutive spring samples in Lake Jed Johnson, but followed no pattern in Lake Rush. Similarly, c/f for bluegills increased in fall samples between years in Lake Jed Johnson, but decreased in Lake Rush. C/f for other species also showed similar fluctuations; only c/f for redear sunfish *(L. microlophus)* increased each year in both lakes, during both spring and fall.

Length frequency distributions of bluegills caught by electrofishing were generally similar between the 2 lakes for most sampling periods. (Fig. 1, 2). The major difference in length frequencies between the 2 lakes occurred in the spring of 1981, when few yearling fish were taken from Lake Jed Johnson, compared with the number taken in Lake Rush. For each Lake and each season we used Chi-square tests to compare length frequencies of bluegills between years. In all 4 tests, differences between years were highly significant ($P < 0.001$).

In both lakes, bluegills and redear sunfish were the most abundant species caught in barrel and frame nets in all years (Tables 6, 7). In both lakes, catches of bluegills and redear sunfish in frame nets increased each year, the catches being greatest in 1981. Catches of other species in frame nets fluctuated between years but did not follow an identifiable trend. Similarly, catches of all species in barrel nets fluctuated between years in both lakes. For both types of net, fluctuations between years in the c/f for all species appeared to be independent of total effort. Furthermore, there was no consistent relation between water temperature and catches between years.

In Lake Jed Johnson, where striped bass × white bass hybrids were stocked, the length frequency distribution of bluegills caught in frame nets was not significantly different among years ($X^2 = 10.487$, 6 df, $P > 0.10$). Similarly, the length

Table 4. Catch of fish per hour of electrofishing during spring and fall in Lake Rush, 1979 - 1981.

	Season and year				
	Spring			Fall	
Species	1979	1980	1981	1979	1980
Bluegill	112.6	30.6	124.1	139.0	88.2
Redear sunfish	34.7	48.6	59.6	15.6	18.5
Longear sunfish	13.7	1.5	24.1	18.7	9.9
Warmouth	11.1	3.3	19.9	17.4	18.2
Green sunfish	14.8	2.7	13.9	35.9	26.5
Largemouth bass	10.8	8.7	27.1	18.3	50.7
Brook silversides	0.9	0.6	0.0	12.0	1.9
Other fish	2.2	3.9	0.6	1.8	3.1
Total number of fish	908	331	447	2085	787
Total effort (hours)	4.5	3.3	1.7	8.6	3.6
Total catch per hour of effort	201.8	100.3	262.9	242.4	218.6

Table 5. Catch of fish per hour of electrofishing during spring and fall in Lake Jed Johnson, 1979 - 1981.

	Season and year				
	Spring			Fall	
Species	1979	1980	1981	1979	1980
Bluegill	93.2	40.2	33.9	36.0	47.6
Redear sunfish	12.3	14.0	16.3	3.4	5.9
Longear sunfish	14.5	7.8	8.2	17.2	20.0
Warmouth	14.8	4.2	3.0	9.9	8.2
Green sunfish	33.2	11.2	7.7	46.9	63.1
Largemouth bass	29.7	12.8	21.4	19.1	27.8
Gizzard shad	5.2	16.8	19.3	3.8	2.9
Brook silversides	1.3	1.1	0.0	8.5	2.9
Other fish	5.5	2.5	4.6	2.1	3.2
Total number of fish	651	396	267	2792	899
Total effort (hours)	3.1	3.6	2.3	19.0	4.9
Total catch per hour of effort	210.0	110.0	116.1	146.9	183.5

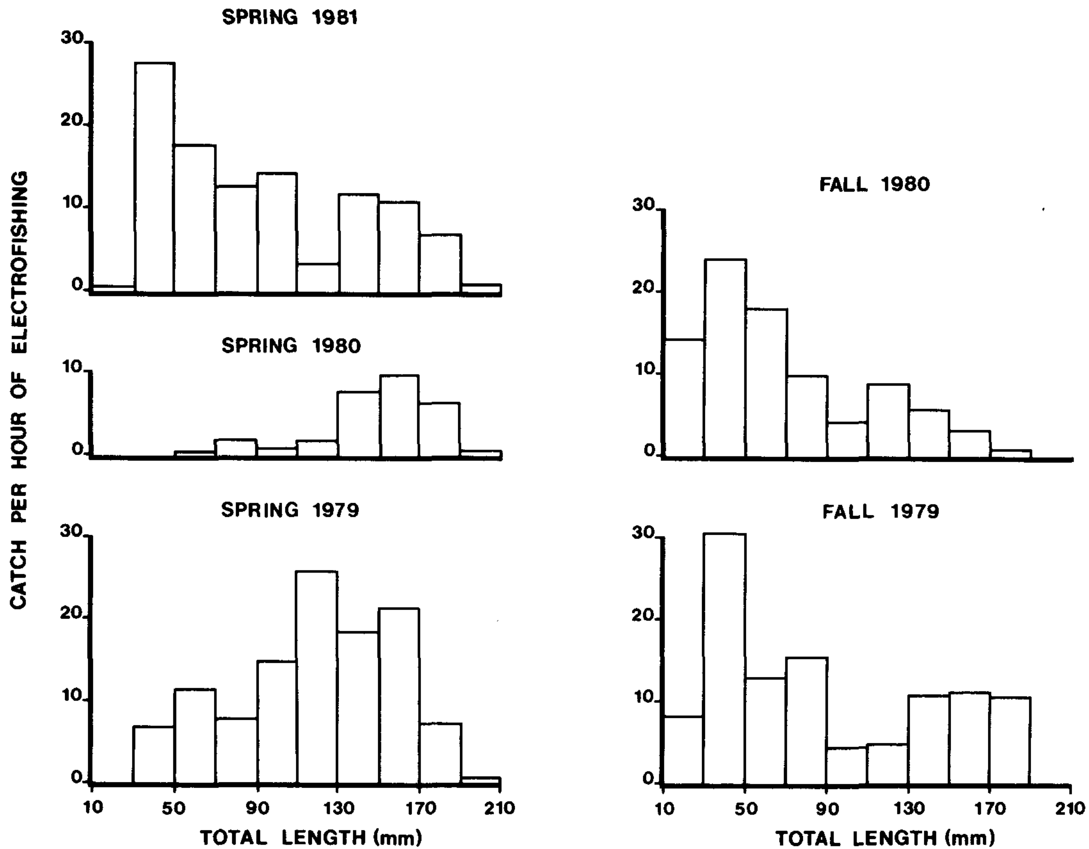

Fig. 1. Catch of bluegills of various lengths per hour of electrofishing in Rush Lake, presented by season.

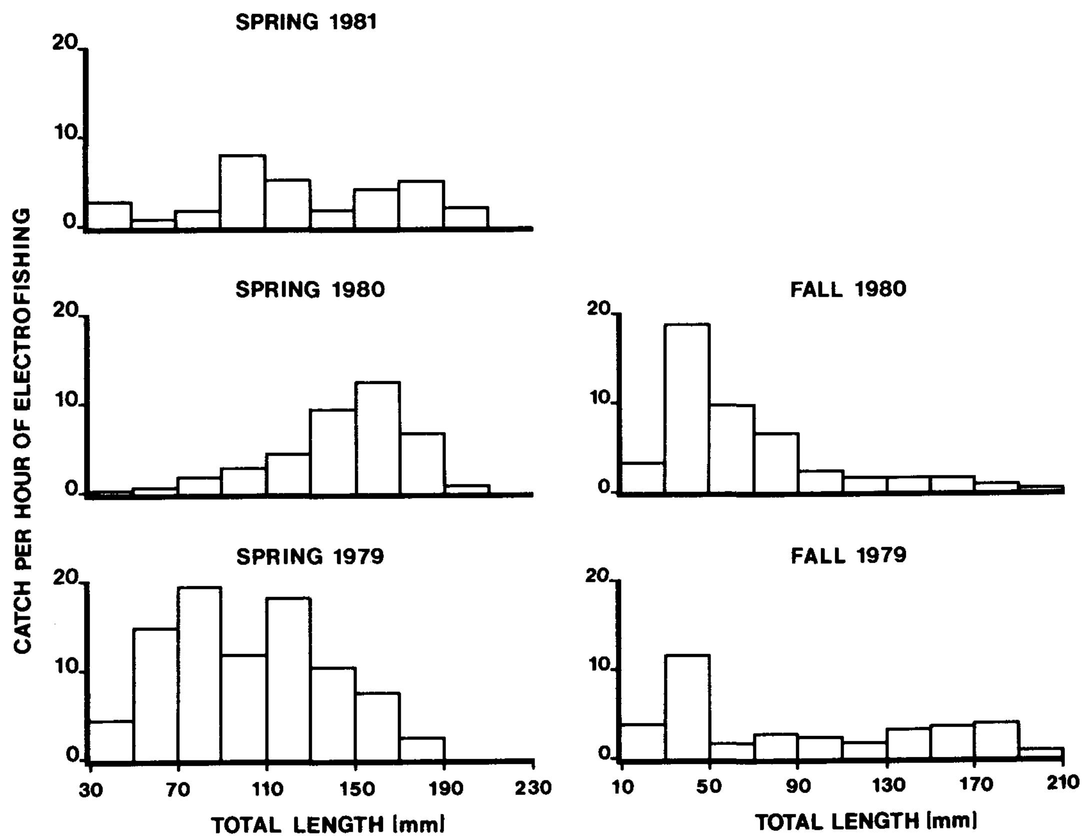

Fig. 2. Catch of bluegills of various lengths per hour of electrofishing in Jed Johnson Lake, presented by season.

Table 6. Catch of various species per net day (24 hours) in barrel nets set in lakes Rush and Jed Johnson, 1979 - 1981.

	Lake and year					
	Rush			Jed Johnson		
Species	1979	1980	1981	1979	1980	1981
Bluegill	1.0	0.4	1.4	0.9	0.3	1.4
Redear sunfish	2.0	6.8	7.8	1.8	0.7	7.5
Other sunfish	0.6	0.4	1.4	0.6	0.3	1.8
Other fish	0.1	0.2	2.5	0.2	0.3	0.2
Total number of fish	121	155	266	125	18	267
Total effort	33.8	19.9	20.3	36.4	11.6	24.3
Total catch of all fish per net day	3.6	7.8	13.1	3.4	1.6	11.0
Mean water temperature (C)	18.8	14.8	22.6	19.2	14.0	22.5

Table 7. Catch of various species per net day (24hours) in frame nets set in lakes Rush and Jed Johnson, 1979 - 1981.

	Lake and year					
	Rush			Jed Johnson		
Species	1979	1980	1981	1979	1980	1981
Bluegill	5.2	7.2	8.4	3.8	7.3	7.4
Redear sunfish	5.3	10.5	21.1	0.9	5.6	9.1
Other sunfish	0.2	2.0	1.8	0.2	4.1	1.5
Other fish	0.3	1.1	1.2	0.0	3.3	1.8
Total number of fish	146	391	532	56	362	322
Total effort	13.4	18.8	16.3	11.6	17.7	16.1
Total catch of all fish per net day	10.9	20.8	32.6	4.8	20.4	20.0
Mean water temperature (C)	18.8	14.8	22.6	19.2	14.0	22.5

frequency distribution of bluegills taken in barrel nets was not significantly different between 1979 and 1981 ($X^2 = 4.706$, 3 df, $P > 0.10$). However, the length frequency distribution of bluegills from barrel nets was significantly different than that of bluegills collected with frame nets ($X^2 = 12.675$, 3 df, $P < 0.01$). Although the correct length frequency distribution of the bluegill population in Lake Jed Johnson is unknown, both types of net apparently selected against fish less than 110 mm long (Fig. 3). Further, the greatly skewed distribution of bluegills taken by frame nets suggests that this gear selected for the larger fish. The length frequency distributions of bluegills collected by the same gears from Lake Rush were similar to those for Lake Jed Johnson and test statistics were also similar.

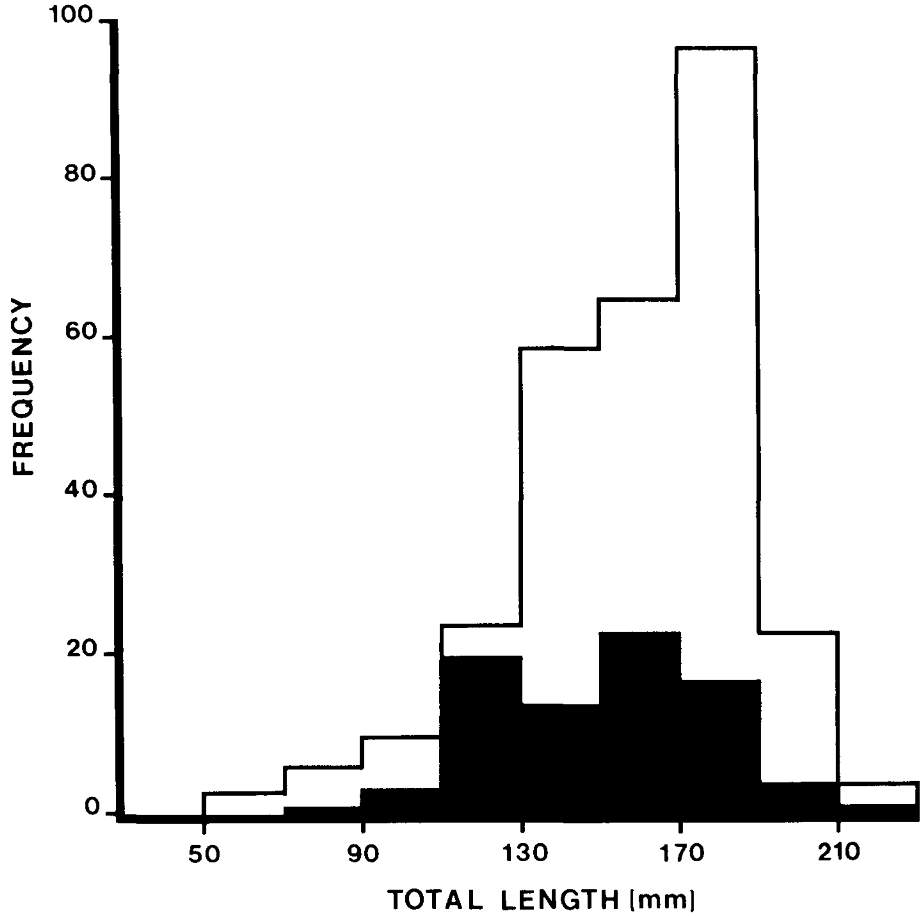

Fig. 3. Length-frequency distribution of bluegills caught in fram nets (open bars) and barrel nets (solid bars) in Jed Johnson Lake during all years.

In both lakes, young-of-the-year (YOY) bluegills were the most abundant fish caught by seining (Fig. 4). In Lake Jed Johnson, although the number of bluegills collected on the 2nd night of each sampling period was strongly correlated with the number collected on the 1st night (Spearman's rho = 0.783), significantly fewer bluegills were caught on the 2nd night (Wilcoxin Signed Ranks Test, T = 3, n = 9, $P < 0.02$). This decrease suggests that bluegills did not randomly redistribute themselves along the lake shore over a 24-hr period; consquently, data collected on the 2nd night were not used in the remaining analysis. There was a poor correlation between abundance of YOY bluegills at the 2 seining sites for the same night (Spearman's rho = 0.196); however, there was no significant difference in abundance between the 2 sites measured over the summer in 1979 (Mann-Whitney Test T = 14.5, n = 6, m = 6, $P > 0.05$) or in 1980 (T = 6, m = 6, n = 3, $P > 0.05$). In other words, a single seine haul on either site may have been a poor measure of overall abundance of bluegills in the lake, but repeated seine hauls made throughout the summer were a good measure of relative abundance. A similar pattern of abundance of redear sunfish in seine hauls was also found. In 1980, YOY bluegills were about 2½ times more abundant in seine hauls (Mann-Whitney Test T = 13, m = 12, n = 9, $P < 0.01$) than in 1979. Significantly more redear sunfish were also collected in 1980 (Mann-Whitney Test T = 10, m = 12, n = 9, $P < 0.01$).

Abundance of brook silversides on various nights and seining sites was poorly correlated (Spearman's rho = 0.288, and 0.134, respectively), suggesting that schools of silversides were randomly distributed along the shoreline on any given night. These data suggest that seine catches may be a poor measure of the relative abundance of silversides in Lake Jed Johnson.

In Lake Rush, significantly fewer bluegills were also collected on the second night of each sampling period (Wilcoxin Signed Ranks Test, T = 5, n = 9, $P < 0.05$) in 1979. There was no significant difference in the number of YOY bluegills collected in 1979 and 1980 (Mann-Whitney Test, T = 11.5, m = 6, n = 4, $P > 0.05$).

DISCUSSION

In striking contrast to previously published studies concerning the stocking of hybrids (Bishop 1968, Logan 1968, Williams 1971, Crandall 1979), we found poor survival of stocked fingerlings and no evidence of survival of fry. Factors that may have reduced survival of hybrids are unknown. All fingerlings appeared to be in excellent condition at time of stocking. Although centrarchids may have preyed on hybrid fry, we found no evidence of it in a concurrent study of the diets of 5 lepomids and largemouth bass (unpublished data).

In Lake Jed Johnson, the distribution of striped bass × white bass hybrids appeared to be restricted primarily to the limnetic zone. All of the hybrids were taken within 1.8 m of the surface in floating gill nets set where the water was 3 to 6 m deep. Furthermore, all of the prey items found in hybrid stomachs live in the benthic or pelagic areas of the limnetic zone in Lake Jed Johnson (unpublished data). Although Baumann and Kitchell (1974) reported that bluegills feed in the limnetic zone, we found few bluegills in this zone, and all were longer than 150 mm. Since larval bluegills are pelagic for about 6 weeks before moving inshore (Werner 1967), and because of the small size of the hybrids stocked, we expected heavy predation by hybrids on these larvae and older juveniles; however, we found few lepomid larvae and no juveniles in stomachs of hybrids. The significantly greater number of YOY bluegills in seine hauls after the introduction of hybrids indicates that predation by hybrids on bluegills was insufficient to limit recruitment. A surprising finding of this study was the fast growth of hybrids in the apparent absence of abundant forage fish in the limnetic zone. Although gizzard shad were present in Lake Jed Johnson, their year class strength appeared to be highly variable and we collected no YOY in either 1979 or 1980; all of the gizzard shad we collected were between 220 and 510 mm long.

Hybrids grew about 170 mm between their 1st and 2nd annulus. Crandall (1979) reported that hybrids grew between 80 and 100 mm during their 2nd year. The difference in growth rates between our study and Crandall's may be related to

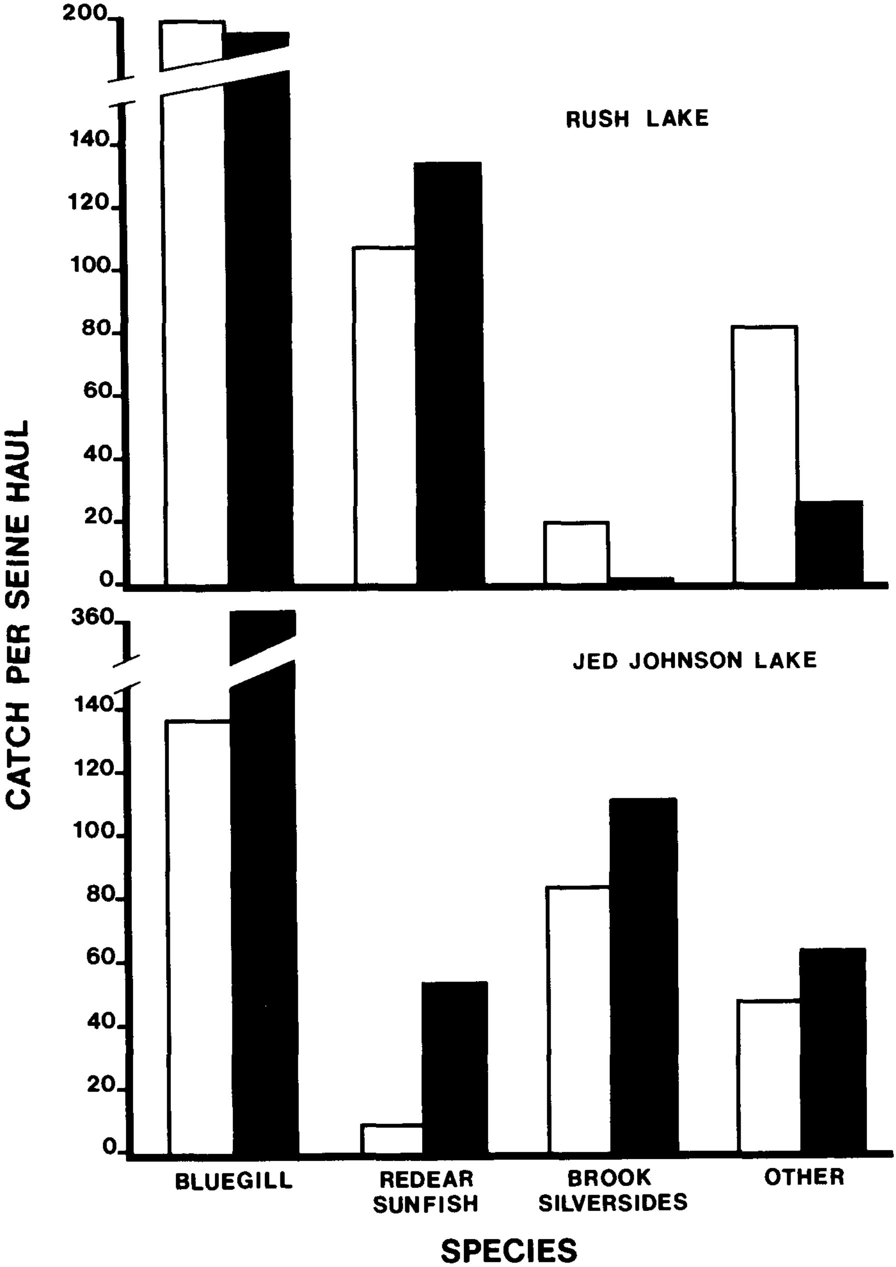

Fig. 4. Catch of young-of-the-year fish per seine haul (c/f) in Rush and Jed Johnson lakes during 1979 (open bars) and 1980 (solid bars).

length of the hybrids at 1st annulus. The fingerling hybrids we stocked in November were about 150 mm shorter than his fish after 1 growing season and probably retained a greater potential for growth.

A major assumption of most field studies, including ours, is that gear selectivity and species vulnerability during a given season remain constant between years. The observed changes in c/f and length frequency distribution of bluegills in Lake Jed Johnson did not appear to be related to predation by hybrids; instead, we believe these changes were the result of both differences in gear efficiency between seasons within years, and within seasons between years. For example, c/f for bluegills > 70 mm was fairly high in the spring of 1979 in Lake Jed Johnson but was low during the following fall. Since the c/f for fish of this size group increased in spring 1980, it is unlikely that a large proportion of this group died between the spring and fall sampling periods in 1979. Similarly, the greatly decreased catch of small bluegills during the spring of 1980 in Lake Jed Johnson does not appear to be the result of hybrid predation, since a similar decrease was observed in Lake Rush. Therefore, we believe that the changes in c/f and the length frequencies observed were related to climatic or other environmental factors that influenced distribution of fish and vulnerability to sampling.

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