EVALUATION OF STRIPED BASS X WHITE BASS HYBRIDS IN A HEATED TEXAS RESERVOIR

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Abstract: This study was conducted to identify habitat factors responsible for the success or failure of a striped bass (*Morone saxatilis*) x white bass (*Morone chrysops*) hybrid introduction and to measure fisherman benefits from the stocking. Hybrids were introduced into Lake Bastrop, Texas, at a rate of approximately 25 fish/ha in 1973, 1974, and 1975. From 1973 through 1977 water samples were analyzed to monitor physicochemical conditions; seining, gillnetting and cove rotenone sampling were accomplished to estimate composition of fish populations; and creel surveys were conducted to measure fisherman effort and harvest. Hybrids exhibited high survival rates but apparently there was insufficient forage to sustain their initial rapid growth. Despite this condition, hybrids attained weights up to 2.0 kg and provided substantial fisherman benefits in terms of harvest and recreation. The monetary value of these benefits was approximately 12 times greater than the costs of the hybrid introduction.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 32: 588-598

Striped bass were introduced into southern reservoirs to improve sport fisheries and act as a biological control of gizzard shad (*Dorosoma cepedianum*). But, striped bass fisheries have developed slowly and consequently many researchers began investigating the striped bass female x white bass male hybrid as an alternative. Logan (1967) reported hybrids exhibited better survival than striped bass when both were stocked in hatchery ponds, and Ware (1974) found growth rates of hybrids in reservoirs were considerably greater than those of striped bass during their first 18 months to 2 years of life.

Their relatively high survival and rapid growth stimulated interest in hybrids as possible sport fish for Texas reservoirs. Information was needed to determine ecological conditions influencing the success of hybrid introductions and if rearing and stocking costs would be economically justified. This study was conducted from 1973 through 1977 to identify the habitat factors affecting hybrids stocked in Lake Bastrop and to measure fisherman benefits from the hybrid introduction.

Appreciation is expressed to the Federal Aid in Fish Restoration Act under project F-31-R of the Texas Parks and Wildlife Department for financial support, and to the Inland Fisheries personnel of the Texas Parks and Wildlife Department who assisted in editing the manuscript.

METHODS

Lake Bastrop is a 367 ha reservoir located approximately 5 km NE of Bastrop, Texas. It is owned by the Lower Colorado River Authority (LCRA) and used to cool the Sim Gideon Steam Generating Station. Fish habitat is limited because most of the lake bottom was cleared prior to filling. However, submerged trees are found in cove areas less than 6 m deep and dense stands of aquatic vegetation usually become established throughout littoral areas during summer months. Lake Bastrop is utilized for fishing, water skiing and camping, and has 2 recreational areas which provide public access.

Provide (1973) described the fishing pressure and harvest, fish community and physicochemical conditions of Lake Bastrop from 1968 through 1972. This information was included with data collected in the present study.

Physicochemical Features

Physicochemical data were collected monthly from 1973 through 1977 at three stations in the reservoir (Fig. 1). Water temperature, dissolved oxygen, pH and specific

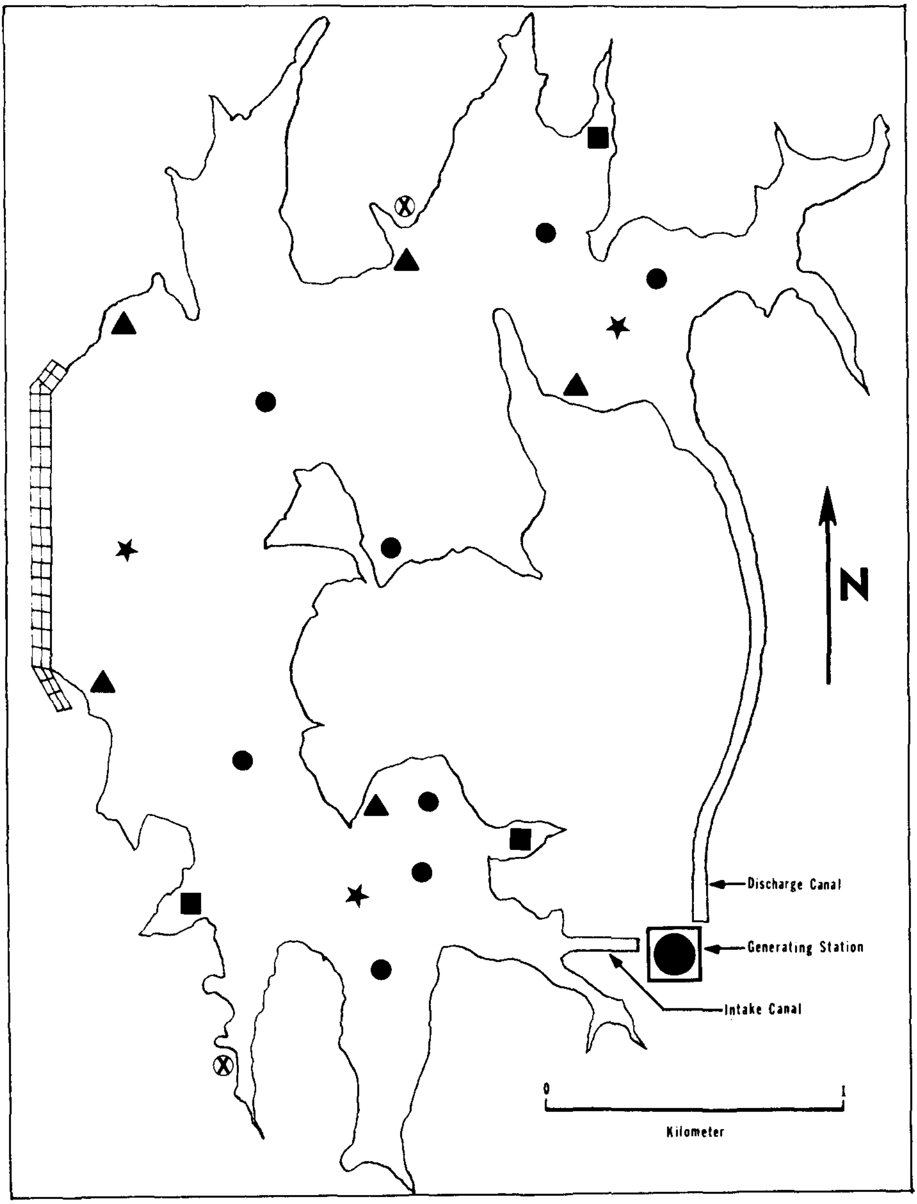

Fig. 1. Lake Bastrop sampling stations for seining (▲), gill netting (●), cove rotenone samples (■), physicochemical samples (★), and creel surveys (⊗).

conductance were measured at 1 m intervals from surface to bottom. Total dissolved solids, total alkalinity, chlorides, sulphates and phosphates were measured only at the surface, mid-depth and bottom. Water temperatures at the intake and discharge canals were measured daily by LCRA personnel.

Fish Populations

Fishes were collected with seines, rotenone and gill nets from 1973 through 1977 to estimate composition of fish populations and identify any changes caused by the introduction of hybrids. Night seining was conducted monthly at 5 stations (Fig. 1) with a 7.6 m bag seine of 6.4 mm mesh. The seine was pulled approximately 15.2 m at each station. All seined fishes were preserved in alcohol and later identified.

Three coves were sampled with rotenone each year in August to estimate standing crops of fishes. Nylon block-off nets (19.1 mm square mesh) were used to prevent fishes from entering or leaving sample areas. Rotenone application and fish processing procedures were similar to those described by Crandall et al. (1976). Standing crop estimates were used to determine available prey to predator ratios (AP:P) for various size classes of predators in the reservoir according to methods presented by Jenkins and Morais (1976).

Experimental gill nets were set monthly at 8 stations. Each net was 45.7 m long with mesh sizes varying from 25.4 to 88.9 mm by 12.7 mm increments, and was constructed according to specifications described by Provine (1973). Fishes collected in gill nets were sorted by species and individually weighed and measured (TL). The condition index (K factor) as defined by Carlander (1953) was calculated by each hybrid collected. Scale samples were taken from hybrids during February, March, and April (1974 through 1976) to compare growth rates of different year classes. Plastic impressions of these scales were examined with a microprojector and the scale readings submitted to the Texas Parks and Wildlife Department's Data Processing Branch for growth analyses.

Food habits of hybrids were determined by examining stomach contents of those collected in gill nets from 1974 through 1976. Food organisms were identified and the number and volume of each type of food item were recorded for each hybrid.

During the summers of 1973, 1974 and 1975 hybrids were stocked into Lake Bastrop at a rate of approximately 25 fish/ha. Each introduction contained fish measuring 50-70 mm TL and all were stocked into open-water areas. Throughout most of the study period the bag limit of hybrids was 1/day, the possession limit was 2.

Sport Fishery

Creel surveys were conducted from 1973 through 1977 to measure fisherman effort and harvest. Surveys were conducted on a specified number of weekdays and weekend days each year. These days were chosen randomly; the total number varied from 45 to 72 days/year. The survey period was from sunrise to sunset.

Creel survey stations were located at the 2 public access points (Fig. 1). The creel clerk was concerned only with completed fishing trips and recorded the following information for each fishing party: (1) number of fishermen, (2) number and bulk weight of each species caught, (3) number of hours fished, and (4) fish species sought.

Annual fishing pressure and harvest were calculated for each species according to methods presented by Provine (1976). To evaluate effects of hybrids on the sport fishery, correlation coefficients were calculated for the relationship between annual harvests of hybrids and indigenous sport fishes. Significance of these correlation coefficients was determined by a t-test.

Costs, harvest benefits and recreational benefits from stocking hybrids were determined on a yearly basis. Cost estimates were based on actual procurement, rearing and stocking expenses. Harvest benefits were determined by placing monetary values on hybrids caught each year by fishermen. Monetary values of hybrids were estimated by obtaining values for striped bass from the Pollution Committee, Southern Division American Fisheries Society (1975) and adjusting these values according to the difference between striped bass and hybrid production costs. The procedures used to apply monetary values to fishes were described by Wegener and Holcomb (1973). Recreational benefits provided by hybrids were determined by multiplying the man-hours fishermen spent seeking this species by the average hourly income of the fishermen, as described by Soileau et al. (1974). In the present study, the average hourly income of persons in Bastrop County (Texas Almanac 1978) was used.

RESULTS AND DISCUSSION

Physicochemical Features

Physicochemical conditions at Lake Bastrop remained relatively constant throughout the study (Table 1). Surface water temperatures were relatively high, ranging from 30.5-34.0 C during summer months, and may have inhibited the growth of fishes. Merriman (1970, according to McNeely and Pearson 1974) reported high water temperatures (35 C) associated with power plant effluents adversely affected the condition of channel catfish (*Ictalurus punctatus*). Water temperatures at Lake Bstrop may have been high enough to inhibit the growth of hybrids during summer months. However, these conditions should not have permanently stunted the hybrids if their growth resumed with the onset of cooler temperatures in the fall. According to Moczygemba and Morris (1977) hybrids at Lake Nasworthy (a heated Texas reservoir) attained weights exceeding 5.0 kg in 3 yr. The average monthly water temperatures at Lake Masworthy as measured by West Texas Utilities Co. personnel were found to be similar (within 1-2 C) to those at Lake Bastrop.

Table 1. Mean annual measurements of physicochemical features, Lake Bastrop, 1972 through 1977. Parenthetical values are the minimum and maximum of each feature.

Parameter	*Year*					
	1972[a]	*1973*	*1974*	*1975*	*1976*	*1977*
[b]Intake Temperature —C	24 (14-32)	23 (12-33)	23 (14-32)	23 (1432)	3 (14-33)	24 (11-33)
[b]Discharge Temperature —C	30 (19-39)	30 (18-39)	30 (19-38)	29 (19-38)	29 (19-39)	30 (17-40)
pH	(7.4-8.3)	(7.4-8.8)	(7.9-8.8)	(7.5-8.4)	(7.2-9.4)	(7.3-9.1)
Specific Conductance (micromhos/cm)	664 (600-805)	735 (680-745)	673 (600-750)	696 (619-765)	713 (650-794)	708 (660-750)
Total Dissolved Solids (ppm)	441 (371-484)	468 (460-475)	431 (405-458)	396 (376-430)	424 (344-482)	455 (356-578)
Total Alkalinity (ppm)	166 (146-177)	166 (160-169)	126 (120-170)	162 (141-174)	138 (111-166)	135 (108-180)
Chlorides (ppm)	102 (98-108)	109 (105-116)	119 (115-132)	109 (105-112)	102 (98-108)	107 (97-116)
Sulfates (ppm)	55 (45-74)	61 (58-63)	79 (60-102)	56 (39-66)	94 (55-123)	94 (77-129)
Phosphates (ppm)	0.50 (---)	0.50 (---)	0.05 (0.01-0.13)	0.04 (0.07-0.64)	0.28 (0.07-0.64)	0.25 (0.05-0.7

[a]Data reported by Provine (1973).

[b]Measurements taken at the intake and discharge canals of Sim Gideon Steam Generating Station.

Fish Populations

Seining data indicated that abundance of most forage species fluctuated slightly from year to year (Table 2). Threadfin shad and tidewater silverside appeared to be most abundant in 1974, but declined substantially in 1975; their numbers remained relatively low through 1977. The decline of these species may have been due to increased predation by introduced hybrids as investigations on other reservoirs have shown reductions in shad populations due to predation by introduced striped bass (Moczygemba and Morris 1977) and white bass (Jester and Jensen 1972).

Table 2. Number of fishes caught per unit of seining effort at Lake Bastrop, 1973 through 1977[a].

	Year				
Species[b]	*1973*	*1974*	*1975*	*1976*	*1977*
Gizzard shad	0.07	0.46	0.01	0.14	0.04
Threadfin shad	2.91	6.72	0.94	1.07	0.19
Carp	0.05	0.08	0.03	0.03	0.00
Golden shiner	0.04	0.48	0.60	0.03	0.11
Blacktail shiner	0.36	0.06	0.01	0.00	0.42
Pugnose minnow	0.67	0.06	0.07	1.17	0.02
Fathead minnow	0.25	0.02	01.3	0.00	0.02
Bullhead minnow	0.00	0.00	0.00	0.10	0.09
Black bullhead	0.00	0.00	0.09	0.00	0.00
Yellow bullhead	0.02	0.04	0.00	0.03	0.00
Channel catfish	0.12	0.36	0.36	0.17	0.08
Tadpole madtom	0.04	0.00	0.00	0.03	0.04
Mosquitofish	1.31	0.20	0.66	0.00	0.08
Tidewater silverside	41.67	148.02	17.51	25.93	40.09
Striped bass x white bass[c]	0.04	0.00	0.01	0.00	0.00
Warmouth	0.98	0.44	0.51	0.55	1.02
Green sunfish	0.78	0.88	3.24	3.62	3.09
Bluegill	39.02	10.80	12.15	45.55	29.13
Longdear sunfish	2.05	1.26	0.87	1.31	2.04
Redear sunfish	4.56	1.04	2.16	3.86	1.58
Spotted bass	0.85	0.90	1.29	0.70	0.40
Largemouth bss	2.93	2.26	2.15	1.48	2.04
Logperch	0.93	0.38	0.33	0.72	0.53
Rio Grande perch	0.00	0.00	0.00	0.03	0.17
Total	99.65	173.46	43.12	86.52	81.18

[a]Unit of effort is defined as one, 15.2-m drag with a 7.6-m bag seine.

[b]Common names were taken from Bailey (1970).

Hybrids were collected the first year they were stocked, and from 1975 through 1977 were the most abundant sport fish (by weight) in gill net collections (Table 3). Hybrids stocked in 1973 grew rapidly and attained weights of 1.4 kg in 1 yr. However, those stocked in 1974 and 1975 did not grow as rapidly; analyses of scale samples revealed slower growth rates of hybrids of these 2 year classes (Table 4). The condition of hybrids also declined; average K-factors fell from 1.38 in 1974 to 1.15 in 1977. The largest hybrid

Table 3. Number and weight of fishes caught per unit of effort with experimental gill nets, Lake Bastrop, 1972 through 1977.[a]

Species[b]	*1972*[c]		*1973*		*1974*		*1975*		*1976*		*1977*	
	Number	*Weight* (kg)	*Number*	*Weight* (kg)	*Number*	*Weight* (kg)	*Number*	*Weight* (kg)	*Number*	*Weight* (kg)	*Number*	*Weight* (kg)
Longnose gar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00
Gizzard shad	4.19	3.40	3.78	3.86	4.79	5.12	4.45	4.31	4.28	3.96	3.41	2.86
Threadfin shad	0.00	0.00	0.01	<0.01	0.00	0.00	0.01	<0.01	0.01	<0.01	0.00	0.00
Carp	1.90	4.51	1.27	4.11	1.52	4.50	1.18	3.66	0.72	2.40	0.66	1.99
River carpsucker	0.06	0.23	0.05	0.21	0.02	0.06	0.02	0.07	0.03	0.11	0.04	0.13
Quillback	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00
Smallmouth buffalo	0.05	0.72	0.02	0.30	0.02	0.19	0.05	0.69	0.07	0.89	0.07	0.74
Blue catfish	*0.34*	*0.41*	*0.23*	*0.42*	*0.16*	*0.38*	*0.10*	*0.41*	*0.03*	*0.28*	*0.03*	*0.12*
Channel catfish	0.51	0.42	0.63	0.73	0.63	0.72	0.88	0.73	0.93	0.67	0.94	0.69
Flathead catfish	0.06	0.37	0.07	0.39	0.03	0.20	0.00	0.00	0.05	0.21	0.10	0.51
Black bullhead	0.02	0.01	0.02	<0.01	0.00	0.00	0.00	0.00	0.01	<0.01	0.00	0.00
Yellow bullhead	0.61	0.15	0.25	0.07	0.01	<0.01	0.02	0.01	0.05	0.01	0.06	0.01
Striped bass x white bass	0.00	0.00	0.30	0.10	0.48	0.99	1.43	2.55	1.14	2.31	0.86	2.08
Warmouth	0.41	0.04	0.44	0.08	0.22	0.04	0.11	0.02	0.17	0.02	0.12	0.02
Green sunfish	0.00	0.00	<0.01	<0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bluegill	2.26	*0.19*	*1.44*	0.13	*0.19*	0.12	*1.48*	0.14	*1.67*	*0.19*	0.74	0.05
Readear sunfish	0.26	0.02	0.28	0.04	0.54	0.03	0.43	0.08	0.69	0.13	0.39	0.06
Longear sunfish	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.01*	*<0.01*	*0.02*	*<0.01*	*0.01*	*<0.01*
Spotted bass	0.06	0.05	0.07	0.07	0.21	0.13	0.10	0.07	0.13	0.08	0.02	0.01
Largemouth bass	0.31	0.19	0.33	0.34	0.20	0.17	0.10	0.10	0.14	0.09	0.07	
White crappie	0.23	0.11	0.29	0.19	0.43	0.38	0.32	0.26	0.46	0.22	0.30	0.22
Black crappie	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Freshwater drum	0.03	0.13	0.02	0.09	0.02	0.12	0.05	0.09	0.12	0.07	0.22	0.29
Total	11.32	10.99	9.23	11.07	10.61	13.18	10.81	13.19	10.70	11.83	8.06	0.85

[a]Unit of effort is defined as one, overnight set of a 45.7-m experimental gill net.
[b]Common names taken from Bailey (1970).
[c]Data reported by Provine (1973).

Table 4. Mean total length (mm) of three year classes of striped bss x white bass hybrids, Lake Bastrop.

Year class	*Number*	*Mean Total Length at Annulus* 1	2	3
1975	40	308		
1974	86	303	404	
1973	134	351	429	466

caught in gill nets was a 3-yr.-old fish weighing approximately 2.0 kg; it was considerably smaller than hybrids of similar age in many southeastern reservoirs. Bishop (1967) collected 3-yr.-old hybrids from Cherokee Lake, Tennessee, which weighed 2.4 kg and Williams (1970) reported 3-yr.-old hybrids in Clark Hill Reservoir, South Carolina, weighed 2.7 kg. Ware (1974) stated hybrids reached sizes of 2.7 - 3.2 kg in 3 years in Tennessee reservoirs.

Cove rotenone sampling indicated standing crops of most fishes varied from year to year (Table 5). These fluctuations probably reflect the variability of cove rotenone estimates as discussed by Hayne et al. (1967). The absence of hybrids from rotenone samples is not unusual as this sampling technique can be ineffective for collecting schooling, pelagic fishes (Carter 1957, Sanderson 1960).

Table 5. Standing crops of fishes (kg/ha) in Lake Bastrop, 1972 through 1977.

Species	Year					
	1972[a]	*1973*	*1974*	*1975*	*1976*	*1977*
Longnose gar	0.00	0.00	0.00	0.00	0.11	0.00
Gizzard shad	2.91	4.03	20.28	10.42	14.90	2.76
Threadfin shad	0.45	3.92	1.61	1.46	0.67	0.80
Carp	37.41	36.29	70.24	46.93	59.92	43.90
Smallmouth buffalo	0.00	0.00	0.00	0.00	0.00	0.00
Blue catfish	1.12	0.34	1.29	0.00	0.00	0.00
Channel catfish	18.26	12.88	25.14	16.69	23.86	15.55
Flathead catfish	1.68	0.01	1.70	0.03	0.00	0.50
Black bullhead	0.45	0.34	0.00	0.11	0.00	0.01
Yellow bullhead	3.02	0.67	0.84	0.34	0.78	0.83
Tidewater silverside	0.01	0.05	0.30	0.11	0.11	0.00
Warmouth	9.52	5.94	4.61	3.70	4.26	4.12
Green sunfish	2.24	1.68	2.95	3.14	6.05	4.12
Bluegill	45.81	49.62	36.15	24.86	30.58	21.20
Longear sunfish	1.90	2.02	1.60	1.68	2.02	2.17
Redear sunfish	25.65	17.02	10.71	12.78	20.27	17.04
Largemouth bass	22.96	36.85	39.80	12.10	15.79	17.37
Spotted bass	<0.01	0.09	1.78	0.45	0.56	0.15
White crappie	0.07	0.12	0.16	0.56	0.22	0.27
Freshwater drum	0.00	0.00	0.00	1.01	2.58	1.52
Rio Grande perch	0.00	0.00	0.31	0.11	0.67	0.76
Total	173.46	171.87	219.47	137.52	183.35	133.07

[a]Data reported by Provine (1973).

Standing crop estimates indicate the slow growth and declining condition of hybrids may have been due to an insufficiency of forage. From 1974 through 1977, AP:P ratios for predators 230-400 mm TL (the approximate sizes of most hybrids) were at or below 1:1 which Jenkins and Morais (1976) reported as the minimum desirable ratio of forage to predators. If standing crops of hybrids could have been estimated, these ratios would have been substantially lower indicating an inadequate supply of forage fishes.

Lake Bastrop did not support large standing crops of shad either before or after the hybrid introductions (Table 5). However, analyses of stomach samples revealed threadfin and gizzard shad were the most utilized forage species (Fig. 2). In 1974 the largest hybrids may have been too small to effectively feed on gizzard shad; this species did not occur in hybrid stomach samples until 1975. Also, in 1974 forage species such as threadfin shad and tidewater silverside were more abundant than small gizzard shad (Table 2). Sunfishes (*Lepomis* spp.) were preyed on, but to a lesser extent than clupeids. Although cove rotenone sampling indicated sunfishes were the most abundant forage species (Table 5), apparently they were not consumed in proportion to their abundance. Investigations by Bishop (1967) and Williams (1970) also showed clupeids to be the preferred food item of hybrids, and Bayless (1972 according to Ware 1974) suggested the success of hybrid introductions may be dependent on shad.

Food habits of hybrids provided further evidence of insufficient forage. From 1974 through 1976 clupeids and other prey species such as tidewater silverside occurred less frequently in the diet of hybrids; increased utilization of alternate food items such as insects was noted (Fig. 2). This trend coincided with the decline of these forage fishes in seining samples (Table 2).

The successive stocking rates, high survival, and restrictive bag limit of hybrids (1/day) may have resulted in an overabundance of this facultative predator which reduced its prey to low numbers. This probably explains the inability of hybrids to maintain their initial growth rates and condition. However, there has been no evidence of natural reproduction by hybrids and consequently their density can be controlled through harvest regulations and stocking. Increasing the bag and possession limits of hybrids would effectively reduce their populations and the predatory pressure they exert on forage items. By monitoring the growth and condition of hybrids, bag limits and stocking rates can be adjusted to prevent hybrids from becoming overabundant and stunted, and still sustain a hybrid fishery.

Sport Fishery

The sport fishery at Lake Bastrop since 1968 has been dominated by largemouth bass and catfishes (Provine 1973). The number and weight of these and other species harvested each year have fluctuated with fishing pressure (Table 6). The introduction of hybrids did not appear to affect this sport fishery as correlation analyses revealed no significant relationship between harvest of hybrids and other species ($P = 0.05$). Similar results were reported by Campbell et al. (1976) who investigated angling pressure and harvest in 23 southern reservoirs (including Lake Bastrop) stocked with non-native sport fishes.

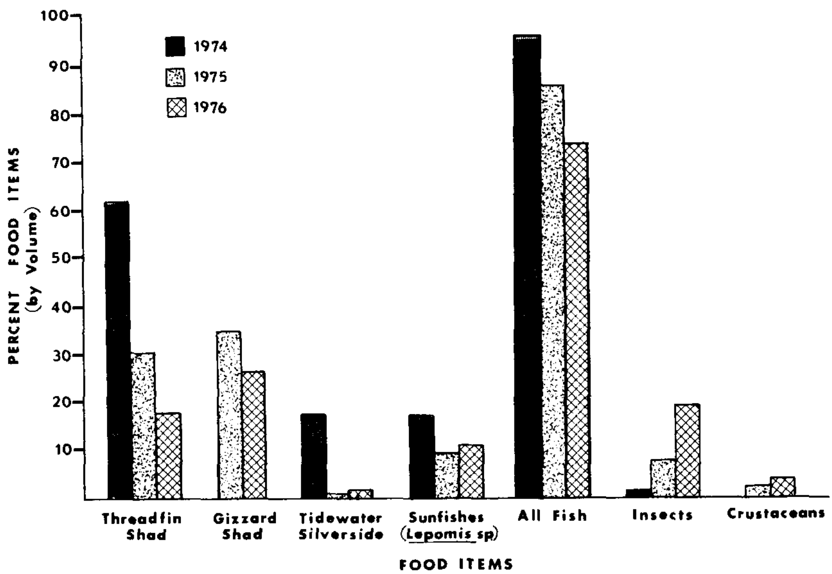

Fig. 2. Percent by volume of food items occurring in striped bass x white bass stomach samples, Lake Bastrop, 1974 through 1976.

Table 6. Numbers and weights of fishes harvested per hectare, and fishing pressure for each species (person-hours/hectare), Lake Bastrop, 1973 through 1977.

SEAGRASS BEDS
(Number samples = 48)

Numerical Species	No.	%	Gravimetric Species	Wt (g)	%
Pinfish	3533	75.4	Pinfish	38230.9	58.2
Silver perch	409	8.7	Striped burrfish	7273.6	11.1
Pigfish	306	6.5	Pigfish	5525.6	8.4
Striped burrfish	72	1.5	Silver perch	3166.3	4.8
Silver jenny	55	1.1	Scrawled cowfish	2668.2	4.1
Gulf toadfish	36	0.8	Gulf toadfish	1766.0	2.7
Dusky pipefish	32	0.7	Atlantic stingray	1470.2	2.2
Gulf pipefish	25	0.5	Southern puffer	1098.1	1.7
Scrawled cowfish	24	0.5	Gulf flounder	641.2	1.0
Fringed filefish	21	0.4	Sea catfish	446.8	0.7
Other	169	3.7	Other	3379.1	5.1
Total	4682		Total	65666.0	

DISCHARGE CANAL
(Number samples = 24)

Numerical Species	No.	%	Gravimetric Species	Wt (g)	%
Sheepshead	12	30.8	Ladyfish	4537.2	30.0
Southern hake	6	15.4	Sheepshead	3259.1	21.5
Atlantic spadefish	3	7.7	Jewfish	1760.8	11.6
Silver jenny	2	5.1	Atlantic spadefish	1412.2	9.3
Ladyfish	2	5.1	Bluefish	1400.0	9.2
Bluefish	2	5.1	Striped mullet	656.1	4.3
Spot	2	5.1	Black drum	482.8	3.2
Black drum	1	2.6	Spot	470.1	3.1
Striped mullet	1	2.6	Atlantic stingray	312.4	2.1
Jewfish	1	2.6	Scrawled cowfish	282.5	1.9
Other	7	17.9	Other	558.1	3.8
Total	39		Total	15131.3	

Hybrids appeared in the creel at Lake Bastrop in 1974 and by 1977 an estimated 1,717 hybrids had been harvested from the lake. The actual total harvest of hybrids was considerably greater than this number; during 1977 fishermen reported catching large numbers of hybrids at night which were not accounted for in daytime creel surveys. The number and weight of hybrids caught per man-hour of fishing pressure for this species were relatively high and exceeded those of largemouth bass in 1975 and 1977; their catch rates were similar in 1976. The mean weight of hybrids caught by fishermen gradually increased from 0.32 to 1.17 kg. Each year the majority of hybrids were caught from January through March. The hybrid fishery thus provided recreation when fishing activity for indigenous sport fishes was relatively slow.

The cost:benefit ratios from stocking hybrids were favorable in terms of harvest and recreational benefits. The monetary value of the hybrid harvest increased from approximately $700 in 1976 to almost $6,000 in 1977, and resulted in a cumulative value of $10,680. Total cost of stocking these fish was less than $1,000 so the cumulative cost:benefit ratio for this harvest was approximately 1:12. Gillnetting data in 1977 revealed a relatively large population of hybrids remain in the lake (Table 3). Apparently the hybrid poplation could have supported more lenient bag limits which would have substantially increased harvest benefits. Recreational benefits provided by introducing hybrids also surpassed their stocking costs. Annual fishing pressure for hybrids gradually increased throughout the study from 0.65 to 3.53 person-hours/ha. The monetary value of this recreation exceeded $4,000 in 1976 and 1977, and resulted in a cumulative value of $12,120. The cumulative cost:benefit ratio for this recreation was approximately 1:13. The favorable benefits shown in both ratios were partly due to the relatively low cost of introducing hybrids, and to their harvestability.

CONCLUSIONS

Growth of hybrids in Lake Bastrop declined due to a scarcity of forage but they did provide substantial fisherman benefits (in terms of harvest and recreation) which greatly surpassed stocking costs. Introductions of hybrids are easily justified from an economic standpoint, and because of their utilization of clupeids, they are desirable predators for many southern reservoirs.

LITERATURE CITED

Bailey, R. M., ed. 1970. A list of common and scientific names of fishes from the United States and Canada, 3rd ed. Am. Fish. Soc. Spec. Publ. 6.

Bayless, J. D. 1972 Artificial propagation and hybridization of striped bass, *Morone saxatilis* (Walbaum). South Carolina Wildl. Dep. 126 pp.

Bishop, R. D. 1967. Evaluation of the striped bass (*Roccus saxatilis*) and white bass (*R. chrysops*) hybrids after two years. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 21:245-254.

Campbell, J. E., E. Hayes, W. R. Chapman, and W. Seawell. 1976. Angling pressure and sport fish harvest in the predator-stocking evaluation reservoirs. Proc. Annu. Conf. Southeast. Assoc. .Fish Wildl. Agencies. 30:114-119.

Carlander, K. D. 1953. Handbook of freshwater fishery biology. Iowa St. Univ. Press, Ames, Iowa. 752 pp.

Carter, B. T. 1957. What significant information can be gained from rotenone population studies in impoundments. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 11:81-84.

Crandall, P. S., B. W. Lyons, and R. W. Luebke. 1976. Evaluation of gill net and rotenone sampling techniques with total reservoir drawdown. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies. 30:222-229.

Hayne, D. W., G. E. Hall, and H. M. Nichols. 1967. An evaluation of cove sampling of fish populations in Douglas Reservoir, Tennessee. Pages 244-297 *in* Reservoir fishery resources symposium. Presented by the Reservoir Comm., S. Div. Am. Fish. Soc. at Univ. Ga., Athens.

Jenkins, R. M., and D. I. Morais. 1976. Prey-predator relations in the predator-stocking evaluation reservoirs. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies. 31:141-157.

Jester, D. B., and B. L. Jensen. 1972. Life history and ecology of the gizzard shad, *Dorosoma cepedianum* (Le Sueur) with reference to Elephant Butte Lake. New Mexico State Univ., Las Cruces, N.M., Agric. Exp. St. Res. Rep. 218. 56 pp.

Logan, H. J, 1967. Comparison of growth and survival rates of striped bass and striped bass x white bass hybrids under controlled environments. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 21:260-263.

McNeely, D. L., and W. D. Pearson. 1974. Distribution and condition of fishes in a small reservoir receiving heated waters. Trans. Am. Fish. Soc. 103:518-530.

Merriman, D. 1970. Does industrial calefaction jeopardize the ecosystem of a long tidal river? International Atomic Energy Agency, United Nations Headquarters, New York. 33 pp.

Moczygemba, J., and D. J. Morris. 1977. Statewide striped bass study. Texas Parks and Wildl. Dept., D-J Fed. Aid Proj. F-31-R-3. Final Rep. 31 pp.

Pollution Committee, Southern Division of the American Fisheries Society. 1975. Monetary values of fishes. Tennessee Wildl. Resources Agency, Nashville, Tenn. 18 pp.

Provine, W. C. 1973. Lake Bastrop channel catfish stocking study. Texas Parks and Wildl. Dep., D-J Fed. Aid Proj. F-12-R-18, Final Rep. 8 pp.

__________. 1976. Cost/benefits from the rotetone renovation of a 485-hectare Texas reservoir. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 30:216-221.

Sanderson, A. E. 1960. Results of sampling the fish population of an 88-acre pond by electrical, chemical and mechanical methods. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 14:185-198.

Soileau, L. D., K. C. Smith, R. Hunter, C. E. Knight, D. M. Soileau, W. E. Shell, Jr., and D. W. Hayne. 1974. Atchafalaya Basin usage study. U.S. Army Corps of Engineers, New Orleans, La. 85 pp.

Texas Almanac. 1978. A. H. Belo Corp. Dallas, Tx. 704 pp.

Ware, F. J. 1974. Progress with Morone hybrids in freshwater. Proc. Annu. Conf. Southeast Assoc. Game Fish Comm. 28:48-54.

Wegener, W., and D. Holcomb. 1973. An economic evaluation of the 1970 fishery in Lake Tohepekaliga, Florida. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:628-634.

Williams, H. M. 1970. Preliminary studies of certain aspects of the life history of the hybrid (striped bass x white bass) in two South Carolina reservoirs. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 24:424-431.