Age, Growth, and Survival of *Morone* Hybrids in Clarks Hill Reservoir, Georgia

Jerome F. Germann, *Georgia Department of Natural Resources, Game and Fish Division, Dearing, GA 30808*

Zan E. Bunch, *Georgia Department of Natural Resources, Game and Fish Division, Dearing, GA 30808*

Abstract: Hybrid bass (*Morone saxatilis* X *Morone chrysops*) age, growth, survival, and condition indices were studied in 1980 and 1981 to gain information needed to refine the hybrid bass stocking program on Clarks Hill Reservoir, Georgia. Age and growth data and survival estimates were derived using scales taken from fish collected with gill nets over a 12-month interval. Average calculated lengths for 1975–1980 year classes were age I, 279 mm; age II, 429 mm; age III, 491 mm; age IV, 536 mm; age V, 598 mm; and age VI, 561 mm. Relative mortality rates were positively correlated with increased stocking densities and catch curve analysis yielded survival estimates of 0.3085 to 0.3985. Condition indices suggested a decrease in hybrid bass condition since 1972. Hybrid bass growth potential and life expectancy are discussed regarding reservoir management and sport fishery utilization.

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The Clarks Hill Reservoir hybrid bass fishery is a put, grow, and take fishery with hybrid bass (*Morone saxatilis* × *Morone chrysops*), playing a dual role as a predator and sport fish. Although Georgia and South Carolina stock large numbers of hybrid bass on an annual basis, the total impact of these hybrid bass on the local fisheries is not known. Optimum future use of this fish depends on the application of correct stocking rates, adequate survival of stocked fish, and good growth rates. Knowledge of the age structure of the population and condition indices would provide needed management data. In short, there eixsts a need to refine the hybrid stocking program to help insure that the right stocking rates be employed to maintain a strong fishery.

In 1984, Richard B. Russell Dam will impound the Savannah River above Clarks Hill Reservoir. Information on the age and growth of hybrid

bass will be a means of evaluating population changes that may occur. The objectives of this study were to determine the age and growth; yearly condition factors, and survival of hybrid bass from Clarks Hill and to compare these results with work done in South Carolina (Williams 1970, 1971, 1972, and 1974). This study was funded through the Dingell-Johnson Federal Aid to Fish Restoration Project F-26, Georgia. Thanks are due to Jo Ann Henderson for typing this manuscript.

Methods

Clarks Hill Reservoir is a U.S. Army Corps of Engineers, 28,340 ha multipurpose impoundment located on the Savannah River between Georgia and South Carolina. Hybrid bass were first introduced into the lake as fry by the South Carolina Wildlife and Marine Resources Department in 1967. Fingerlings have been stocked annually since 1971 at densities ranging from 0.04 to 41.40/ha (Table 1).

Scales were taken from hybrid bass which were captured during a food habits study (Germann 1982). Fish were collected 1 July 1980 through 24 June 1981 with sinking-type gill nets with mesh sizes of 3.2 cm, 3.8 cm, 5.1 cm, 6.4 cm, or 7.6 cm. All nets were 1.8 m deep and either 30.4 m or 91.2 m long. Nets were set at 2 of 5 predetermined areas on a monthly schedule. A minimum of 50 hybrid bass were captured monthly with the exception of April and October in which 150 hybrids were sought. Catch rates were determined using catch net hour. One net hour was defined as 1 91.2 m net

Table 1. Numbers of hybrid bass stocked in Clarks Hill Reservoir 1967–1982.

Year	Fry		Fingerling	
	N	*N*/Ha[a]	*N*	*N*/Ha
1967	3,260,000	115.0	0	0
1968	2,910,000	102.7	5,000	0.2
1969	6,970,000	245.9	0	0
1970	5,320,000	187.7	0	0
1971	12,640,000	446.0	5,000	0.2
1972	4,500,000	158.8	1,100	0.04
1973	4,500,000	158.8	28,000	1.0
1974	0	0	102,402	3.6
1975	2,500,000	88.2	224,000	7.9
1976	0	0	627,474	22.1
1977	0	0	504,601	17.8
1978	0	0	745,330	26.3
1979	0	0	1,058,935	37.4
1980	0	0	998,640	35.2
1981	0	0	1,173,471	41.4
1982	0	0	683,612	24.1

[a] Surface area is 28,340 ha at full pool.

fished 1 hour. Catches were analyzed to determine population densities at the various sampling locations (Gooch 1977).

Fish were weighed to the nearest gram and measured in millimeters for total length. Scales were taken from the dorso-lateral field near the point on the body touched by the posterior extremity of the pectoral fin. Age was determined from scale impressions made on cellulose-acetate strips and measured at 43× magnification. Length at each annulus was calculated using the Lee method (Lagler 1956). Preliminary analyses indicated that growth rates were similar between the sexes, so all data were pooled in subsequent analyses. The average annual length increments at ages I and II were compared to the numbers stocked for 6 year classes using linear regression techniques.

The effect of stocking density on survival was evaluated by computing relative annual mortality rates (RM) using a formula developed by Van Den Avyle and Higginbotham (1979). The equation is as follows:

$$RM = -[\ln(Nc/Ns]/\Delta t,$$

where Nc = the number of fish collected from a particular year class,

Ns = the number stocked for the same year class and

t = the average time elapsed in years between stocking and capture for the Nc fish.

Survival was estimated using simple estimates involving the ratio of fish at age_t to fish at age_{t+1} and catch curve analysis estimates which plot logarithms of frequency of occurrence of fish against the ages of the fish (Ricker 1963). In both methods, the assumption that recruitment is constant was not met because this population is propogated by stocking. Reproduction of hybrid bass may occur; however, validated progeny were not common enough to satisfy this assumption. Survival estimates can still provide insight into the life history of stocked hybrids.

Condition indices and length-weight equations were developed to describe the relative well-being of the hybrid bass population.

Results

Age and Growth

Between 1 July 1980 and 24 June 1981, 1,049 hybrid bass scale samples were collected. Approximately 73% were captured in 3.8-cm mesh gill nets. Catch rates varied from 4.6 fish/net hour at Mosley Creek (Station 4) to 0.12 fish/net hour at the confluence of the Broad and Savannah River (Station, Table 2).

Non-parametric ranking tests demonstrated that samples taken from all locations in the lake except for Station 1 were from populations of similar

Table 2. Catches of hybrid bass at Clarks Hill Reservoir using 3.8 mm sinking gill nets, July 1980–June 1981.

Location	*N* times nets set per area	*N* hours per area	*N* hybrid bass caught	Fish per net hour	*N* months sampled
Broad & Savannah River confluences	5	58.75	7	0.12[a]	2
Murry Creek	26	168.11	297	1.77	7
Camp Creek	7	66.16	190	2.87	4
Mosley Creek	11	67.36	287	4.26	6
Clay Hill	14	123.74	259	2.09	6
Total	63	418.01	1,040	2.49	

[a] Gill net catches at this location were significantly different from other sites.

densities, i.e., they were of the same abundance. The hybrid bass in Clarks Hill appeared to be evenly dispersed throughout the lake.

The scale radius-body length relationship for hybrid bass in Clarks Hill was length (L) = 65.4176 + 1.6641 scale radius (mm). Ott and Malvestuto (1981) described the hybrid bass relation in West Points Alabama/Georgia as L = 56.3912 + 1.2179 (radius). Their fish ranged from 80 to 501 mm total length, whereas Clarks Hill fish ranged from 227 to 736 mm total length.

Lengths after the first year of growth for hybrid bass ranged from 259 mm for the 1977 year class to 315 mm for the 1975 year class (Table 3). The average calculated length for all fish at age I was 279 mm. Hybrid bass reached 600 mm by age class V. Calculated lengths for age classes I through IV suggested a decrease in length by age with the more recent introductions. Length for age class II fish showed a significant negative correlation ($r = 0.897$, $P = 0.05$) with successive years. A change in length attained in the second year of growth occurred between 1976 and 1977, 1 year after stocking rates had increased to 22 fish/ha. No relationship was demonstrated among the other age classes.

Williams (1974) aged hybrid bass from Clarks Hill that represented year classes 1968 through 1973. The average calculated lengths for age classes I through V were 266 mm, 454 mm, 525 mm, 550 mm and 607 mm, respectively. Except for age class I fish, the average lengths for each age class were 14 to 34 mm longer than the respective age class fish in this study.

The average annual length increment for age classes I and II was compared to numbers stocked in corresponding years. Correlation tests indicated there was no relationship between annual length increments and number of hybrids stocked.

Survival

Relative mortality rates increased with stocking density for 1975 to 1979 year classes (Table 4) indicating that survival was enhanced at the lower

Table 3. Calculated average total lengths (mm) for respective age classes of hybrid bass from Clarks Hill Reservoir July 1980–June 1981.

			Age class						
Year class	Year collected	*N* collected	0	I	II	III	IV	V	VI
1980	1980	216	285						
1980	1981	176		290					
1979	1980	206		282					
	1981	149		283	428				
	All	355		282	428				
1978	1980	133		270	425				
	1981	86		272	433	487			
	All	219		271	428	487			
1977	1980	42		257	427	487			
	1981	29		262	432	496	525		
	All	71		259	429	491	525		
1976	1980	6		306	465	522	558		
	1981	4		265	459	530	564	600	
	All	10		290	464	525	560	600	
1975	1980	1		313	482	543	605	640	
	1981	1		317	460	514	531	547	561
	All	2		315	471	528	568	594	561
Weighted average length (mm)				279	429	491	536	598	561
Weighted average annual increment (mm)				279	156	58	31	32	14

stocking rates (Fig. 1). The correlation coefficient between relative mortality and stocking density (0.959) was significant at $P = 0.05$, $r = 0.878$.

Catch curve analysis using hybrid bass caught in 1980 and 1981 yielded survival estimates of 0.3085 and 0.3985, respectively. Williams (1981*a*) sampled hybrid bass in Clarks Hill for survival checks. Fitting his 1980 data to catch curve analysis gave an estimated survival of 0.2865. Catch curve analysis of data collected by Williaws in 1976 (Williams 1977) yielded an estimate of 0.3230. Simple survival estimates using data from Table 3 indicated that the survival rate between ages I and II was 0.7520. The estimates for ages III and IV decreased to 0.2984. Survival appeared to be high in early years but then declined rapidly.

Condition indices varied from 1.23 in September to 1.09 in May. The average condition factor for the period sampled was 1.18. Values in the spring months were generally lower than those for the rest of the year. Lower condition factors probably reflected the absence of shad in the hybrid diets as noted

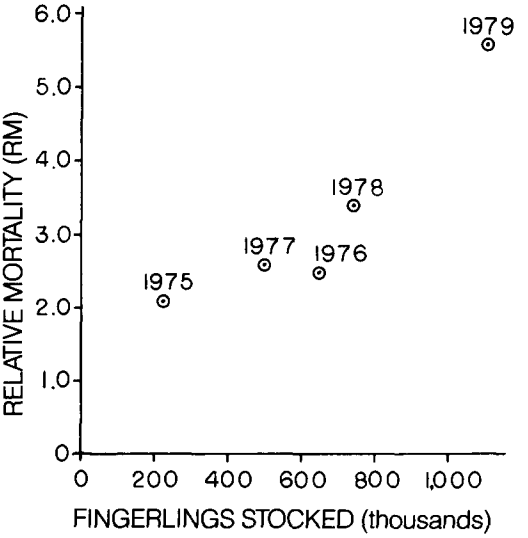

Figure 1. Relative mortality (RM) rates and stocking densities for hybrid bass year classes 1975 to 1979, Clarks Hill Reservoir, Georgia.

by Germann (1982). The length-weight relationship was log W = 4.7432 + 2.9340 log L (r = 0.9713).

Discussion

Age and Growth

Catches of hybrid bass in the Broad-Savannah River confluence (Station 1) differed from catches in all other areas of Clarks Hill. One possible explanation is that the hybrid utilizes the lentic habitat of the lake most of the year. In the spring months, hybrid bass tend to congregate at specific sites usually associated with riverine habitats. The samples in the Broad-Savannah River

Table 4. Number stocked, number captured and relative mortality (RM) of hybrid bass for year classes 1975–1979, Clarks Hill Reservoir.

Year stocked	*N* stocked	*N* captured 1980	*N* captured 1981	Total	Average years elapsed	RM
1975	224,000	1	1	2	5.50	2.11
1976	627,474	6	4	10	4.40	2.51
1977	504,601	42	29	71	3.41	2.60
1978	745,330	133	86	219	2.39	3.40
1979	1,060,835	206	149	355	1.42	5.64

area were taken in October and June, months when the fish should have been in the more lake-like area.

If Station 1 had been sampled in the spring, hybrid bass catches should have been greater than 0.12 fish/net hour (Table 2). In April 1982, Station 1 was sampled. A total of 11.3 net hours yielded 14.30 hybrid bass/net hour, which reflected the increased density of hybrid bass during the spring.

All areas showed monthly and seasonal differences in catch. These deviations were probably the results of fish movements and weather conditions and not the result of several different hybrid bass populations occurring in different arms of the reservoir.

Rapid growth of hybrid bass during the first 2 years of life has been documented. Ware (1974) found that hybrid bass grew to an average of 363 mm at age I and 447 mm at age II. Hybrid bass growth in Clarks Hill Reservoir as described by Williams (1970) was somewhat slower for age I fish, (251 mm) but comparable for age II fish (452 mm). During this study, hybrid bass growth in the first 2 years averaged 279 mm and 429 mm, respectively. Growth was also within the ranges reported by other investigators (Bishop 1967, Crandall 1978).

Information on the growth potential of the hybrid bass and its life span have not been well defined. Ware (1974) noted that specimens larger than 4.0 kg or older than 5.5 years occurred infrequently. Williams (1971) reported that the growth rate of hybrid bass rapidly declined with increased age. At that time, hybrid bass were being utilized as a substitute for striped bass as predators on gizzard shad populations. For the hybrid bass to be capable of utilizing the larger shad in open waters, growth would either have to be rapid over a short period of time or extend over a period of years. In this study, overall hybrid bass growth declined after the third year of life (Table 3).

Survival

Reservoir managers hoped that the hybrid bass would inherit the long life span of the striped bass, 30 to 40 years (Mansueti and Hollis 1963), rather than that of the shorter-lived white bass which is usually 4 to 5 years (Yellayi and Kilambi 1975). It appears from this study that hybrid bass in Clarks Hill exhibit a life expectancy similar to white bass. In 1,200 gill net hours over 12 months, 1,416 hybrid bass were captured; however, only 2 hybrid bass captured were 5 years old or older.

There have been several catches of individual hybrid bass 6 years old or older. Ware (1974) mentioned an 8- or 9-year-old state record hybrid bass in Tennessee weighing 8.2 kg. In 1982, a world record hybrid bass was caught in the Savannah River above Augusta, Georgia, that weighed 9.4 kg and was 815 mm long. Subsequent aging of its scales showed that this fish was age VIII+. However, these fish are exceptions and the data indicated that the majority of hybrids live 3 to 4 years in Clarks Hill.

Hybrid bass in Clarks Hill Reservoir are a popular sport fish and have become a highly desired species by anglers (Williams 1981*b*). Although hybrid bass have not been able to fulfill the role as predators on gizzard shad, they have been found to fully utilize the smaller threadfin shad which are generally found in excess in many southeastern reservoirs (Ott and Malvestuto 1981, German 1982).

Knowledge of the short life span of hybrid bass should be incorporated into the management scheme for reservoirs. For instance, current fishing regulations in Georgia allow for daily harvest of 10 hybrid bass in waters bordering South Carolina and 6 hybrid bass in all other waters. In view of the short life span of hybrid bass and its popularity with fisherman, consideration may need to be given to increasing the creel limits to increase the hybrid bass harvest. Liberalized creel limits should provide better utilization of the hybrid stock.

Williams (1971 and 1972) gave condition factors of hybrid bass in 0.1 inch intervals. Generally, the values were between 1.25 and 1.50. The values in this study were less and indicated a decrease in overall plumpness of the hybrid bass. Since 1972, the stocking rates of fingerlings have increased from 0.04 fish/ha to 35.2 fish/ha in 1980 (Table 1). Crandall (1978) found that hybrid condition declined from an average of 1.38 in 1974 to 1.15 in 1977 with a constant stocking rate of approximately 25 fish/ha in a Texas reservoir. He related this decline to the development of insufficient forage through time due to the hybrid bass.

Increased numbers of hybrid bass fingerlings stocked was related to a decrease in survival rates of stocked fish (Tables 1 and 4). Relative mortality appeared to increase when the stocking rate exceeded 22 fingerlings/ha. Below this stocking level, rates were similar. Length-weight equations for October 1979–1982 (Table 5) indicated a rather stable situation in hybrid bass condition since 1979. Although values differed from year to year, the weight differences/given length were not significant, usually less than 0.07 kg. Apparently, the shift in condition occurred prior to 1979. The relationship of numbers of hybrid bass stocked and subsequent survival rates should be studied further to determine the most appropriate stocking-survival ratios.

Table 5. Length–weight equations of hybrid bass for October 1979–1982, Clarks Hill Reservoir.

Year	Log W =	Correlation coefficient	*N* of observations
1979	−4.7079 + 2.9294 Log L	0.9131	380
1980	−5.0326 + 3.0429 Log L	0.9962	297
1981	−4.6629 + 2.9027 Log L	0.9851	362
1982	−5.0058 + 3.0431 Log L	0.9311	202

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