FISH POPULATION CHANGES IN KEYSTONE RESERVOIR FOURTEEN YEARS AFTER STRIPED BASS INTRODUCTIONS

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Abstract: During the 14 years after initial introduction, a viable striped bass *(Morone saxatilis)* sport fishery developed on Keystone Reservoir. Natural reproduction, first identified in 1970, continued through 1979 in tributary rivers. Selected endemic fish species showed no significant changes in standing crop estimates from cove rotenone studies 1971-73, 1976-79. Available prey-predator ratios (AP/P) showed a fluctuating availability of forage for small predators and ample prey for large predators.

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The establishment of a freshwater population of striped bass in Santee-Cooper Reservoir by 1954 (Scruggs and Fuller 1954) raised the possibility of adding this large pelagic predator to other reservoir systems as an additional sport fish. The initial success of striped bass in South Carolina led to widespread stockings. Presently, 38 states have established striped bass fisheries.

Although striped bass have been stocked extensively in the southeast to control overabundant clupeid populations composed of large individuals, relatively few striped bass populations have shown an effect on either clupeids or other native fishes. Effects on prey populations by striped bass and striped bass x white bass *(Morone chrysops)* hybrid populations have been reported by Stevens (1964) in South Carolina, Ware (1974) in Florida, Hart (1978) in Virginia, and Crandall (1978) and Morris and Follis (1978) in Texas impoundments. The effect of striped bass predation on clupeids and endemic sport fishes has been reported in South Carolina (Fuller 1968) and California (McCammon and von Geldern 1979).

The potential value of a large pelagic predator to control gizzard shad *(Dorosoma cepedianum)* populations in Oklahoma led to the introduction of striped bass in 1965. The objective of this study was to review the status of important endemic sport and forage fish populations in Keystone Reservoir following development of the striped bass population. The study was funded by the Federal Aid in Fish Restorations Project, Oklahoma, F-29-R.

METHODS

Keystone Reservoir, a 10,643 ha flood control—hydroelectric reservoir impounded in 1965, received 2.75 million striped bass from 1965 - 1969. Natural reproduction was first identified from the Arkansas River tributary of Keystone Reservoir in 1970 (Mensinger 1970).

The relative abundance of striped bass fingerlings in Keystone Reservoir was used as an index of future year class strength. Relative abundance of striped bass fingerlings was determined from shoreline seine samples collected between 15 June and 15 August. Seining operations used drag seines 12 m in length, 2 m in depth with a bar mesh size of 5 mm. Procedures followed those developed by Mensinger (1970). All striped bass fingerlings captured were counted and released.

Estimates of fingerling survival in Keystone were based on the number of striped bass captured by seining a known cumulative distance (4572 m) and comparing that value to the previous years catch and estimate in the same distance. Initial fingerling estimates were

based on the number of striped bass stocked during that year. The proportion for fingerling survival estimates was as follows:

$$ax = bc$$

Where: a = previous year's catch

b = the present catch

c = previous year's estimate of fingerling survival

x = the present estimate of fingerling survival

Standing crop estimates were made from 2 coves of similar habitat in accordance with procedures of the Reservoir Committee, Southern Division of the American Fisheries Society (Grinstead et al. 1976). The coves were utilized as reference coves during the standing crop studies of 1971 - 73, 1976-79 and were compared for population trends of selected species from Keystone Reservoir. A Friedman nonparametric test (Marascuilo and McSweeney 1977), for matched samples, was utilized to determine significant changes in standing crops from 1971-73, 1976-79. Available prey-predator ratios (AP/P) (Jenkins and Morais 1976) were developed for Keystone by the National Reservoir Research Program, U.S. Fish and Wildlife Service, from standing crop data recovered from cove rotenone operations. With this information, trends in forage availability in Keystone Reservoir could be examined.

RESULTS AND DISCUSSION

Since striped bass reproduction was confirmed in Keystone Reservoir in 1970, shoreline seining operations have verified successful reproduction from both the Arkansas and Cimarron River tributaries for 10 consecutive years (Table 1). The annual spawning

Table 1. Number of striped bass fingerlings captured, fingerling survival estimates, and tributaries showing successful spawning activity from shoreline seining operations (15 June - 15 August) 1970-79 on Keystone Reservoir.

Year	Fingerlings in Sample	Fingerling Survival Estimate in Millions	Tributary Spawned
1970	NA[1]	1.45	Arkansas River
1971	157	0.98	Arkansas River
1972	410	2.86	Arkansas River
1973	574	4.00	Arkansas and Cimarron Rivers
1974	227	1.60	Arkansas River
1975	177	1.34	Arkansas River
1976	1439	10.03	Arkansas River
1977	305	2.13	Arkansas River
1978	840	5.86	Arkansas and Cimarron Rivers
1979	1048	7.31	Arkansas and Cimarron Rivers

[1]Data not available

success and relative fingerling abundance of striped bass indicate a population buildup of sexually mature fish from 1970 to 1976 resulting in a dramatic increase in fingerling production. Spawning estimates remained high through 1979, indicating the establishment of a stable spawning population in Keystone Reservoir.

Anglers began harvesting striped bass in Keystone Reservoir in 1970 (Kim Erickson, personal communication, Oklahoma Dept. Wildl. Cons.). In 1975 anglers harvested 0.041 fish/h and 0.056 kg/h while not specifically seeking striped bass (Summers 1978). Creel surveys of Keystone during 1979 showed that striped bass harvest success among all angler harvests had remained virtually unchanged with catch rates of 0.052 fish/ha and 0.048 kg/h (Combs 1980). Anglers specifically seeking striped bass during 1979 showed catch rates of 0.224 fish/h and 0.375 kg/h in Keystone. The striped bass fishery in Keystone Reservoir remains popular with a continued increase in angling pressure for striped bass (Combs 1980). Angler harvest success for important endemic sport species during 1979 showed desirable harvest rates among anglers pursuing specific sport fish: black bass *(Micropterus* spp.) (0.303 fish/h and 0.179 kg/h); white crappie *(Pomoxis annularis)* (0.698 fish/h and 0.0876 kg/h); white bass 0.525 fish/h and 0.063 kg/h; and channel catfish *(Ictalurus punctatus)* 0.827 fish/h.

Fish population studies were conducted during 7 (1971-73 and 1976-79) of the 14 post-impoundment years on Keystone Reservoir. Standing crop estimates were made on selective endemic sport and forage species (Table 2). Important native sport fish to Oklahoma anglers are largemouth bass *(Micropterus salmoides)*, channel catfish, crappie *(Pomoxis sp.)*, and white bass (Mense 1978). These sport fishes were selected for standing crop analysis along with sunfish and gizzard shad.

Table 2. Standing crop estimates (kg/ha) from Keystone Reservoir population studies 1971-73, 1976-79.

Species	1971	1972	1973	1976	1977	1978	1979
Black bass	12.6	3.2	7.3	11.9	11.4	11.9	15.6
White bass	9.4	15.0	2.4	10.8	5.5	21.1	10.8
Channel catfish	24.1	18.9	18.6	26.9	13.6	20.1	17.4
Crappie	4.5	4.9	13.1	10.6	8.8	1.2	0.8
Striped bass	0.7	0.1	0.1	0.2	0.1	1.4	4.4
Sunfish	43.3	59.2	48.1	68.5	58.6	69.6	44.8
Gizzard shad	1317.2	290.6	685.7	1218.7	834.1	2067.2	1265.5

Black bass standing crops in Keystone were primarily made up of largemouth bass with small numbers of spotted bass *(Micropterus punctulatus)*. Although standing crops (kg/ha) of black bass were considerably lower than the state average of 24.7 kg/ha (Greg Summers, personal communication, Okla. Dept. Wildl. Cons.), they remained fairly stable over the years. The coefficient of variation (C.V.) of the standing crop was 33.1 percent. During the latter population studies (1976-79) stability of black bass populations became more pronounced with a coefficient of variation of 15.4 percent.

Harvestable populations of channel catfish well above the statewide average standing crop of 11.4 kg/ha developed early in Keystone Reservoir. The standing crop estimates for channel catfish showed it to have the most stable endemic sport fish population with little fluctuation over the 9 year period (C.V. 22.0%). Channel catfish have become a preferred sport fish in Keystone Reservoir with increases in angling pressure and harvest rates (Combs 1980).

Populations of crappie and white bass displayed large fluctuations in Keystone Reservoir. White bass, demonstrated to be cyclic in nature (Chadwick et al. 1966), showed widely fluctuating standing crops (2.4 to 21.1 kg/ha) in Keystone. The coefficient of variation of these fluctuating standing crops was 57.2 percent. Although standing crops of white bass fluctuated widely in Keystone, they were higher than the state average of 6.2 kg/ha (Greg Summers, personal communication, Okla. Dept. Wild. Cons.) during all years of analysis except 1973. Standing crop estimates for crappie (primarily white crappie), an important sport fish in Keystone, also fluctuated widely during 1971-79 (C.V. 74.7%). Starett and McNeil (1952) reported that crappie abundance was cyclic, with a 3 to 5 year cycle. Unlike white bass, crappie standing crops were generally lower than statewide averages (1.3 kg/ha) and have declined since 1976. Although crappie are preyed upon by striped bass in Keystone Reservoir, their occurrence in the diet (3.6%) was found to be of minor importance (Combs 1978). The widely fluctuating standing crops in Keystone Reservoir may be the cyclic nature of white bass and crappie rather than effects of striped bass populations.

Standing crop estimates of striped bass from cove rotenone studies undoubtedly fail to reflect the status of adult standing stocks in a reservoir but may reflect the adult status through estimates of the standing crop of young-of-year. Striped bass standing crops, primarily consisting of young-of-year fish, reflected the strength of the year class during late summer. The standing crop estimates vary greatly (C.V. 156.6%) showing a general increase from 1976 to 1979.

Endemic forage species of importance in Keystone Reservoir are sunfish and gizzard shad. Sunfishes as a group included bluegill *(Lepomis macrochirus)*, green *(L. cyanellus)*, longear *(L. megalotis)*, orangespotted *(L. humilis)*, redear *(L. microlophus)*, and warmouth sunfish *(L. gulosus)*. These combined species remained the most stable fish populations in Keystone from 1971-1979. Standing crop estimates ranged from 43 to 69 kg/ha with a coefficient of variation of 19.4 percent. The biomass of shad found in the reference coves on Keystone was consistently greater than the statewide average standing crop of 302.7 kg/ha. Standing crop estimates ranged from nearly 300 kg/ha to 2000 kg/ha with no apparent population trend. Shad populations were highly variable with a coefficient of variation of 51.5 percent. Statistical analysis of the standing crop estimates from cove rotenone studies showed no significant variation ($P > 0.05$) between years for any selected endemic sport or forage species.

Gizzard shad length frequencies (Fig. 1) showed little change with no apparent trend during the annual population studies. The dominant forage size of shad ranged from 76 to 152 mm in total length during the study period. Numbers of larger gizzard shad ($>$ 178 mm), never a dominant forage size, have decreased from approximately 27 percent of the total population in 1971 and 1972 to 1 percent in 1978 and 1979. During this time shad longer than 254 mm virtually disappeared from the population. Stomach content studies from Keystone Reservoir (Combs 1978) showed gizzard shad to be the principal forage item (83% by volume) of striped bass. During that period (1974-75) shad found in striped bass stomachs ranged from 25 to 241 mm with a mode of 76 mm in total length. It is unknown whether the decreases in standing crops of larger shad were the result of an environmental response rather than an effect of an established striped bass population.

Available prey-predator ratios (AP/P) were determined on the reference coves from the 1972-73 and 1976-79 standing crop studies on Keystone. The AP/P ratios (Fig. 2, 3, and 4) shows that during 1972 and 1973 adequate forage was available for all predators in the system, while from 1976 to 1978 the forage base for smaller predators ($<$ 127 mm in 1976 and 1978 and $<$ 178 mm in 1977) was inadequate. The prey-predator ratio determined from 1979 standing crop estimates showed that adequate prey was again available for predators of all size classes. The relationship during each year showed that there was an abundance of forage to support large-sized predators such as adult striped bass.

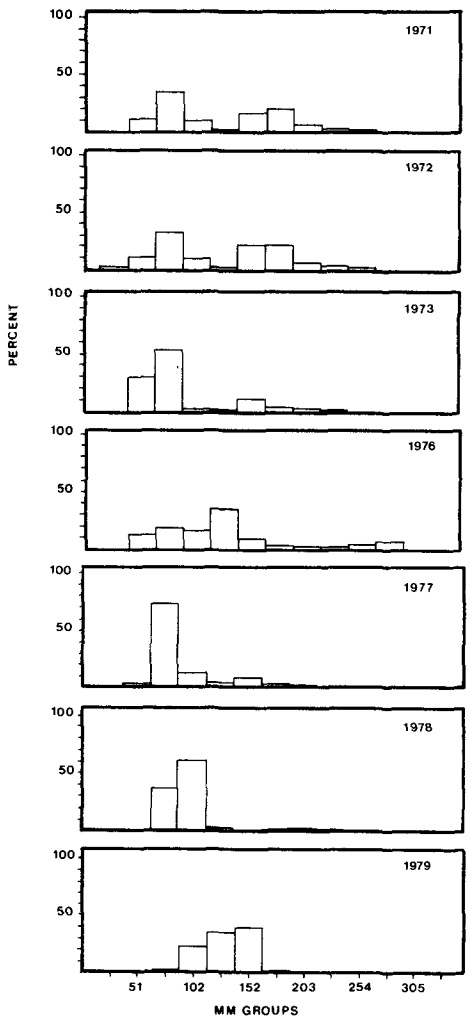

Fig. 1. Length-frequency distributions of gizzard shad from Keystone Reservoir population studies 1971-73 and 1976-79.

The apparent effects of clupeid control and the resulting benefits to fish reported for the Santee-Cooper Reservoir (Stevens 1964, Fuller 1968) leading to widespread introductions have primarily been reported from relatively small impoundments of California, Florida, and Texas. McCammon and von Geldern (1979) reported that following striped bass introductions on Lakes Mendocino and Millerton, California, a declining bluegill and bass fishery increased in harvest and harvestable size. Striped bass populations were unable to control clupeids in Millerton Lake until supplemental stockings began later in the study. Ware (1974) reported that introductions of striped bass in Lakes Hunter and Julinana resulted in standing crop reductions of shad of 50 and 80 percent respectively. In Texas, Crandall (1978) reported virtual elimination of clupeid forage as a result of high density

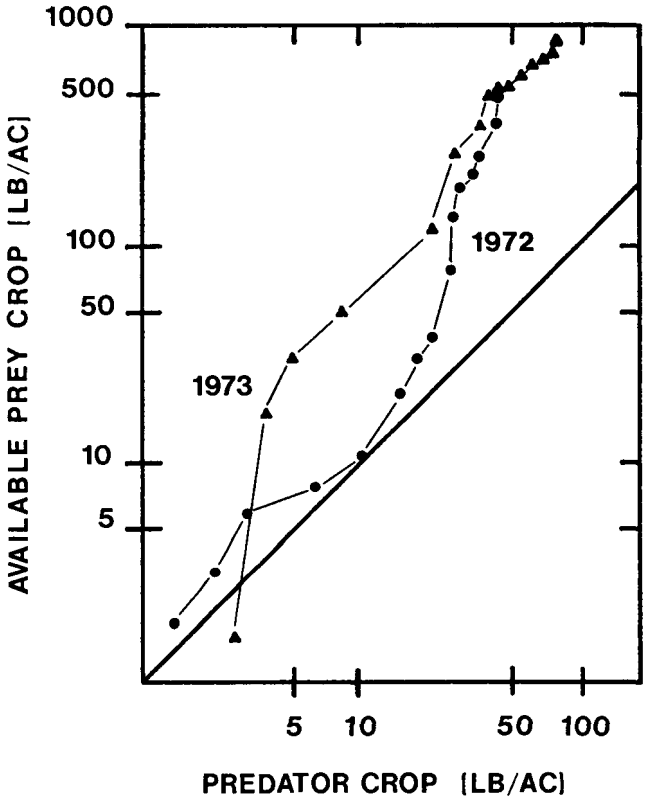

Fig. 2. Prey-predator relationships (AP/P) from Keystone Reservoir population studies 1972 and 1973.

(25/ha) striped bass x white bass hybrid introductions. Native sport fish standing crops appeared unaffected during the period of striped bass introduction and clupeid decline. Morris and Follis (1978) reported the elimination of specific length groups of shad (76 to 178 mm total length) which were attributed to striped bass predation. Clupeid standing crop reductions by striped bass populations in large reservoirs appears restricted to Smith Mountain Reservoir, Virginia, (Hart 1978) where shad populations were reported to have declined from 1973 to 1975.

Unlike the Santee-Cooper Reservoir, important endemic sport and forage fishes in Keystone Reservoir showed little effects that could be attributed to the establishment and buildup of a reproducing striped bass population. Standing crop estimates of important sport and forage fish populations, such as black bass and sunfish, have shown stability while fluctuating sport fish populations (crappie and white bass) showed no apparent detrimental population trends. Indications are that striped bass, occupying a previously untenated niche, has been successfully introduced without affecting other fish populations. The present study of selected endemic fish populations in Keystone supports Bailey's (1974) analysis that introductions have had no noticable effect on native fishes in most southeastern reservoirs.

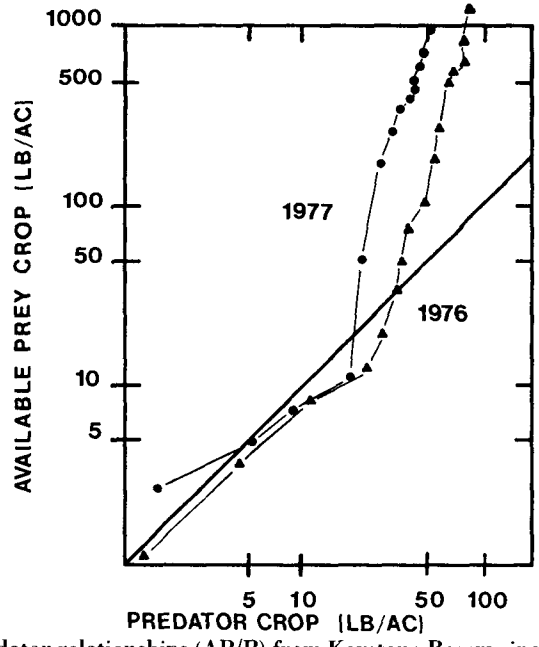

Fig. 3. Prey-predator relationships (AP/P) from Keystone Reservoir population studies 1976 and 1977.

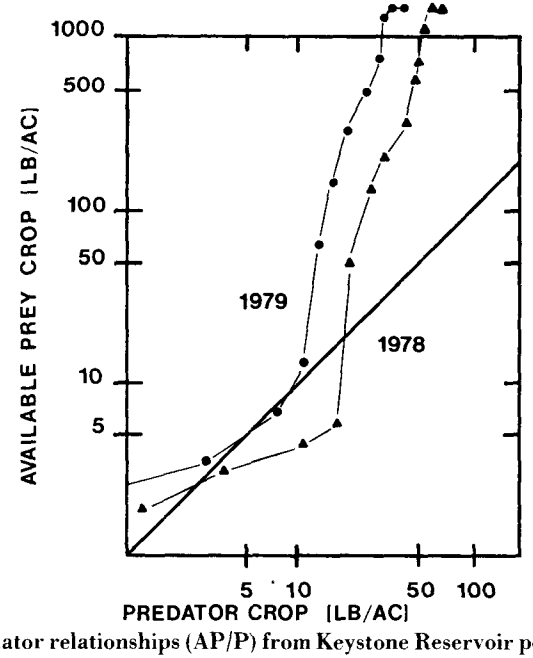

Fig. 4. Prey-predator relationships (AP/P) from Keystone Reservoir populations studies 1978 and 1979.

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