POPULATION DYNAMICS OF LARGEMOUTH BASS IN DEGRAY LAKE, ARKANSAS, 1975-1979

MICHAEL R. DEWEY, U.S. Fish and Wildlife Service, Arkadelphia, AR 71923.
THOMAS E. MOEN, U.S. Fish and Wildlife Service, Arkadelphia, AR 71923.

Abstract: Estimates of abundance, production, growth, survival, and mortality of largemouth bass were derived from spring electrofishing samples in the upper, middle, and lower sections of DeGray Lake from 1975 to 1979. Mean population estimates ranged from 86 to 163 bass per hectare; the populations were dominated by bass of ages I and II (73% to 96%). Population estimates of the 3 coves based on surface area were biased because there were large differences in the ratio of shoreline length to surface area. Population estimates were adjusted to correct for this bias. Production was highest in the midlake section each year. Mean production estimates, based on spring electrofishing samples, ranged from 19.1 to 30.9 kg/ha. The greatest production of tissue and highest mortality occurred during the 2nd year of life. Harvest data indicated that 29.3% of the estimated spring standing crop of largemouth bass was taken by angling in 1977, and 26.8% in 1978.

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Since 1975, DeGray Lake, Arkansas, has been the site of intensive water quality and biological studies in a cooperative effort involving the National Reservoir Research Program of the U.S. Fish and Wildlife Service, the Arkansas Game and Fish Commission, and the Waterways Experiment Station, U.S. Army Corps of Engineers. These studies were initiated to evaluate the effects of altering the release depth of water from a reservoir on the biota and water quality of the lake, and to develop an ecosystem simulation model for predicting these effects in other similar reservoirs. The eight-year field program includes studies for 4 years (1975-78) when the water is released from the epilimnion and 4 years (1979-82) when it is released from the hypolimnion.

Largemouth bass (*Micropterus salmoides*) are the most abundant predators in DeGray Lake and were chosen for intensive study. Population dynamics of largemouth bass were studied during epilimnial release to determine annual trends in abundance, production, growth, survival, mortality, and spatial distribution in the lake.

Largemouth bass of all age groups migrate to shoreline areas before spawning and are vulnerable to nighttime electrofishing (Bryant and Houser 1971). After testing electrofishing through several seasons, Houser and Rainwater (1975) concluded that samples taken in the spring provided the most representative estimates of age composition and abundance. Seawell and Havel (1978) stated that the technique of electrofishing along shore and marking and recapturing fish is useful in estimating bass populations in large impoundments. The collection of large samples, in which all sizes and age groups are represented, provides data suitable for annual comparisons.

METHODS

DeGray Lake, located in the Ouachita Mountains of west central Arkansas, was impounded in 1969. The dam is located on the Caddo River 11.2 km north of Arkadelphia, Arkansas. At normal pool elevation (124.4 m, above mean sea level, msl), the area of the reservoir is 5,428 hectare (ha), and maximum and mean depths are 57 m and 15 m. The reservoir extends in a west-northwest direction for about 32 km and has a shoreline 207 km long. The dam is fitted with a multi-level outlet structure that enables the release of water from either the epilimnion or hypolimnion. During the present study, water was released from the epilimnion.

For sampling, the lake was divided into 3 sections — uplake, midlake, and downlake — to determine spatial variation in largemouth bass population dynamics. The 3 sections had areas of 1,238, 2,549, and 1,661 ha and shoreline lengths of 92, 120, and 121 km, respectively. Spring population estimates were made in 3 coves — one representing each section of the reservoir. These coves (uplake, midlake, and downlake) had shoreline lengths of 1.6, 4.2, and 2.7 km and surface areas of 4.9, 49.4, and 9.7 ha.

A boom-type, boat-mounted electroshocker with variable pulsed, direct current was used each spring (1975 - 79) to make shoreline population estimates of largemouth bass. Estimates were made in late April when water temperatures were 16 to 18C. All sampling was done at night.

Population estimates were based on the mark and recapture method described by Bryant and Houser (1971). Estimates were made after four consecutive nights of electrofishing; a complete circuit of the cove was made each night. All bass were counted, weighed, and measured (total length), and scale samples were taken for age determination. The caudal fin was clipped from bass 250 mm long or less, and larger fish were tagged with Floy dart tags. Population estimates were expressed as fish per hectare. Because coves differed greatly in the relation of shoreline length to surface area, a bias is introduced when numbers or weight of bass are compared on a surface area basis. Populations from coves excompassing large surface areas in relation to shoreline length were understimated when compared on an areal basis. To compensate for this bias, we derived adjustment factors in two steps. First, we determined ratios of shoreline length to surface area (m/ha) for each sample cove. These ratios were 326.5, 84.9, and 278.4 m/ha for the uplake, midlake and downlake coves, respectively. Second, we adjusted the midlake and downlake coves to the uplake cove, which had the highest shoreline to surface ratio, by dividing the shoreline to surface area ratio of each cove into that of the uplake cove. Population estimates (number of bass per hectare) were then multiplied by the appropriate adjustment factors: 1.00 for the uplake cove, 3.84 for the midlake cove, and 1.17 for the downlake cove.

Age and growth estimates were based on empirical data from 7,710 bass collected during spring population estimates. Since the fish were collected before the beginning of the growing season, each fish was credited with an annulus at the outer edge of the scale.

Ivlev (1966) defined production as the total elaboration of fish tissue during time interval ΔT, including that formed by individuals that do not survive to the end of ΔT. We used the method of Chapman (1968) to calculate production of largemouth bass. Numbers of bass per hectare, together with average weight of

fish in each age class, were used to calculate annual production for each section of the lake. Data collected in August in cove sampling with rotenone were used to estimate production of young-of-the-year fish. Such samples were taken in each section of the lake in 1975 - 79.

RESULTS

Population Estimates

Annual sample size (total number of largemouth bass collected from 3 coves) ranged from 1,137 to 1,898. Lakewide mean population estimates ranged from 86 to 163 bass per hectare (Table 1). The estimates decreased steadily from 1975 through 1978, but the trend was reversed in 1979.

Table 1. Population estimates (number of largemouth bass per hectare) for coves in different sections of DeGray Lake (95% confidence intervals in parentheses), and lakewide mean estimates, 1975-79.

	Cove			
	Uplake	Midlake	Downlake	Lakewide Mean
1975	110	202	140	163
	(86-147)	(161-302)	(114-183)	
1976	142	175	63	134
	(116-182)	(146-227)	(45-98)	
1977	144	84	75	95
	(105-200)	(53-102)	(56-113)	
1978	75	103	66	86
	(50-119)	(78-140)	(53-156)	
1979	101	137	91	115
	(62-193)	(102-192)	(62-153)	
Mean	114	140	87	119
SD	29.1	48.9	31.6	30.9
CV	25.5	34.9	36.3	25.9

Variation between sample sites was high. However, there appeared to be no direct relationship between the fluctuations of the estimates among the coves, except in 1979, when estimated numbers increased in each cove. Population estimates were highest in the midlake cove each year except in 1977 (Table 1). This relation agrees with August cove samples, which indicated that the standing crop of largemouth bass was highest in the midlake area each year (Multi-Outlet Reservoir Studies, unpubl. data).

Lakewide, the population of largemouth bass was dominated by fish of ages I and II. Age I made up 30 to 85% (mean, 62%) of the total number, and the ages I and II combined made up 73 to 96% (mean, 89%; Table 2). Bass of ages I and II showed the greatest year-to-year variation in abundance. Abundance of fish of all age groups varied less in the uplake section than in the other two sections.

Table 2. Estimated age composition (by percentage) of largemouth bass in DeGray Lake, 1975 - 79.

Cove and year of collection	Number of fish in sample	Age groups								
		I	II	III	IV	V	VI	VII	VIII	IX
Uplake										
1975	396	80.1	8.1	6.1	3.0	1.5	0.5	0.5	0.2	
1976	475	83.4	11.2	2.7	1.0	0.4	0.6	0.6		
1977	355	61.4	30.1	5.6	0.6	0.8	0.8	0.8		
1978	254	79.5	14.2	5.1	0.8					
1979	253	70.3	25.3	2.0	0.8		0.4	0.8	0.4	
Midlake										
1975	862	61.2	20.3	12.2	2.7	0.9	0.6	0.5	1.2	0.4
1976	1,009	56.9	35.9	3.9	1.9	0.2	0.6	0.4	0.1	0.2
1977	461	38.7	49.4	7.7	0.9	1.1	1.1	0.9	0.2	
1978	868	85.3	7.9	3.6	0.9	1.4	0.3	0.6		
1979	848	61.3	33.5	1.6	1.3	1.1	0.5	0.4	0.4	
Downlake										
1975	640	50.5	31.6	14.1	1.2	0.3	0.5	0.8	0.9	0.1
1976	276	42.0	42.0	7.2	4.7	0.7	1.4	1.8		
1977	321	30.5	42.7	18.1	2.5	2.2	2.5	0.3	0.3	0.6
1978	309	72.2	13.3	6.8	3.6	0.9	1.6	1.3	0.3	
1979	383	56.1	35.5	3.7	1.8	1.8	0.3	0.3	0.3	0.3

The age composition of the bass collected in 1975 and 1976 indicated successful year-classes in both 1974 and 1975. A large percentage of fish in groups I and II were collected in the uplake and midlake coves in both years, and in the downlake cove in 1975 (Table 2). The 1977 year class was also relatively strong as shown by the abundance of age I fish in 1978 in all 3 coves, and the relatively high percentage of age II fish in 1979.

Production

Lakewide production of largemouth bass averaged 26.6 kg/ha during the 4-year study. These estimates were relatively stable from 1975 - 76 to 1977 - 78 and declined in 1978 - 79 (Table 3). Production was highest in the midlake cove each year, where estimates remained relatively stable after declining substantially in 1976 - 77. Patterns of annual fluctuation in the uplake and downlake coves were similar but differed somewhat from that in the midlake cove.

Production was estimated for 9 year classes at various ages (Table 4). For the 2 year classes for which the most data are available (those of 1974 and 1975), production was greatest during the 2nd year of life. However, for the 1976 and 1977 year classes production was greatest during the 1st year of life. Substantial growth occurred during the 3rd year, but because total mortality rates were high,

Table 3. Annual production (kg/ha) of largemouth bass estimated from spring electrofishing collections by cove, DeGray Lake, 1975 - 79.

Years of capture	Cove			Lakewide mean
	Uplake	Midlake	Downlake	
1975-76[a]	18.9	42.6	21.6	30.9
1976-77	21.2	31.9	30.2	29.1
1977-78	20.1	31.5	25.7	27.2
1978-79	14.3	26.3	11.5	19.1

[a] Collections were made in April of these 2 years and production was determined for the year between sampling periods.

most of the production contributed by a single year class was made during the 1st 2 growing seasons.

Annual survival rates were estimated from ratios of the total number of bass per hectare (less age I bass) to the total number in the preceding year. Survival was generally lowest in the upper section of the lake (Table 5).

Instantaneous mortality rates (z) were relatively high, corresponding to low survival rates. Mortality was highest (mean, 0.76; range 0.21 - 0.86) from age I and II. Mortality from age II to III ranged from 0.45 - 0.91 (mean, 0.71), and from age III to IV, 0.31 - 0.92 (mean, 0.63).

DISCUSSION

Population and production estimates were compared per kilometer of shoreline and per hectare of surface area. The midlake cove, which consistently had the largest number of bass per kilometer of shoreline, had the lowest number and biomass of bass per unit of surface area. Data from cove samples taken in August also indicated that the midlake section had the highest standing crop of bass (Multi-Outlet Reservoir Studies, unplubl. data). The midlake cove, in which the ratio of shoreline to surface area (meters of shoreline/hectares of surface area) is low, did not have a proportionately larger number of bass onshore when compared with coves with higher shoreline to surface area ratios. We believe that the adjustments of population estimates, although somewhat arbitrary, are necessary when comparing population estimates (on a surface area basis) from coves with large differences in ratios of shoreline length to surface area. These adjustments for the midlake cove have made biomass estimates from spring electroshocking more closely comparable to May cove sample data from the midlake section of the lake (Multi-Outlet Reservoir Studies, unpubl. data).

Mean production estimates for DeGray Lake (19.1 - 30.9 kg/ha) were comparable to production estimates reported by Houser and Rainwater (1975) for Beaver Lake, Arkansas, from 1968 to 1971 (14.4 - 35.5 kg/ha). Their production estimates for Bull Shoals Lake (1.9 - 14.4 kg/ha) were consistently lower than those found for DeGray Lake.

The highest production by year-class from DeGray Lake (30.3 kg/ha) was lower than the production of 40.3 kg/ha by the strong 1968 year class from Beaver Lake reported by Houser and Rainwater (1975). However, production by the 2 year

Table 4. Estimated production of largemouth bass (kg/ha) in DeGray Lake by year class, 1975 - 79.

Year class and year of collection	Age groups	Cove			Lakewide mean	Total production by year class
		Uplake	Midlake	Downlake		
1970						1.0
1975-76	V – VI	0.5	1.9		1.0	
1971						1.0
1975-76	IV – V	0.4	1.1	0.1	0.6	
1978-79	VII – VIII		0.7	0.1	0.4	
1972						4.9
1975-76	III – IV	1.4	4.2	1.4	2.7	
1976-77	IV – V	0.3	1.3	1.3	1.1	
1977-78	V – VI		1.5	1.0	1.0	
1978-79	VI – VIII		0.1	0.2	0.1	
1973						4.6
1975-76	II – III	1.6	3.8	3.6	3.2	
1976-77	III – IV	1.2	1.1	0.7	1.0	
1977-78	IV – V			0.8	0.2	
1978-79	V – VI		0.4	0.2	0.2	
1974						30.3
1974-75	0 – I	3.3	17.7	5.4	8.9	
1975-76	I – II	7.8	18.4	10.9	13.7	
1976-77	II – III	3.0	6.5	4.6	5.1	
1977-78	III – IV	1.5	2.3	2.0	2.0	
1978-79	IV – V		0.7	0.8	0.6	
1975						25.9
1975-76	0 – I	7.7	11.5	5.6	8.4	
1976-77	I – II	12.8	13.4	7.5	11.5	
1977-78	II – III	3.8	5.7	4.1	4.8	
1978-79	III – IV	1.5	1.1	1.1	1.2	
1976						15.4
1976-77	0 – I	3.9	6.9	13.4	8.2	
1977-78	I – II	6.8	7.3	4.4	6.3	
1978-79	II – III	2.0	0.6	0.5	0.9	
1977						23.2
1977-78	0 – I	8.0	23.0	9.7	15.6	
1978-79	I – II	6.3	9.9	15.0	7.6	
1978						8.1
1978-79	0 – I	4.5	12.8	3.6	8.1	

Table 5. Annual survival (S) and instantaneous mortality rates (Z) for largemouth bass in DeGray Lake, 1975 - 78.

Years of capture	Cove					
	Uplake		Midlake		Downlake	
	S	Z	S	Z	S	Z
1975-76	0.22	1.53	0.45	0.79	0.26	1.35
1976-77	0.39	0.94	0.24	1.41	0.81[a]	0.20
1977-78	0.15	1.90	0.28	1.26	0.35	1.04
1978-79	0.33	1.11	1.01[a]	0.04	0.83[a]	0.19

[a] Number of age II bass collected exceeded the number of age I bass collected in the previous year.

classes from DeGray Lake for which the most data are available (30.5 and 26.1 kg/ha) was much higher than the highest year class production given for Bull Shoals Lake (21.0 kg/ha) (Houser and Rainwater 1975).

DeGray Lake data indicate that production was greatest during the 1st 2 years of life. Houser and Rainwater (1975) found production greatest during the 3rd year of life in Beaver and Bull Shoals Lakes.

At the onset of this study, we anticipated that production of bass would be closely related to production of shad (*Dorosoma* sp.). Shad production was highest in the upper section of the lake each year (Multi-Outlet Reservoir Studies, unpubl. data). No significant correlation was noted between production of shad and of largemouth bass when they were compared by sections. Studies of food of largemouth bass in DeGray Lake by Bryant and Moen (1980) showed that sunfishes were the principal prey (28% by weight), followed by shad (23%). The maintainance of the largemouth bass population is apparently dependent mainly on prey other than shad.

Mortality of largemouth bass in DeGrey Lake was highest (0.76) between ages I and II. Zweiacker and Brown (1971) found mortality rates to be highest for ages I and VI bass in Lake Carl Blackwell, Oklahoma. Houser and Rainwater (1971) found mortality to be greatest from ages II to III in Beaver and Bull Shoals lakes. Bass less than 350 mm long made up 69% of the total harvest of largemouth bass from DeGray Lake in 1977 and 61% of the catch in 1978 (Multi-Outlet Reservoir Studies, unpubl. data). Age and growth analysis indicated that most of these bass would be of ages I or II. As stated earlier, these are also the ages at which the greatest production occurred.

The harvest of largemouth bass in DeGray Lake was 7.4 kg/ha in 1977 and 5.1 kg/ha in 1978 (Multi-Outlet Reservoir Studies, unpubl. data). These values represent 29.3% and 26.8% of the standing crop of bass present in spring population estimates. The harvest of 14.2 bass/ha in 1977 and 9.6 bass/ha in 1978 represents 14.9% and 11.1% of the estimated number from spring electroshocking. These data indicate that natural mortality was more important than fishing mortality in contributing to the high mortality rates found in DeGray Lake. Jenkins (1979), in estimating surplus production of largemouth bass in DeGray Lake in 1977, postulated that natural mortality was the principal factor in predator population dynamics.

The high mortality rate of largemouth bass in DeGray Lake results in a rapid turnover of the population. A relatively high and consistent rate of recruitment from 1975 to 1978 maintained the population. A trend toward fluctuating recruitment, as is characteristic of largemouth bass populations in many older reservoirs, would have a pronounced impact on the DeGray Lake largemouth bass population. Production and population levels were high enough for the bass population to withstand high mortality rates in 1975 - 79; this relation should continue unless recruitment is poor for an extended period.

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