# Age, Growth, and Mortality of Florida Largemouth Bass Utilizing Otoliths

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*Abstract:* Age composition, growth, and mortality of largemouth bass (*Micropterus salmoides floridanus*) populations in 6 major Florida resources were determined. Most largemouth bass were in the first 4 or 5 year classes; however, 6 and 7 year old fish were not uncommon, and largemouth bass up to 12 years of age were collected. Females grew faster and exhibited greater longevity than males. Total annual mortality ($A$) estimated from catch curves ranged from 0.37 for the Suwannee River to 0.54 in Lake Weir and was within the range reported from other localities. Back-calculated lengths based on transversely sectioned otoliths did not differ significantly ($P < 0.05$) from empirical lengths for largemouth bass from Lake Kissimmee. Florida largemouth bass typically reached harvestable-size (>242 mm) during age 1+, but slower growing fish did not recruit into the sportfishery until age 2 or older. Trophy-size largemouth bass (>3.63 kg) ranged from 6 to 12 years of age.

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The Florida subspecies of largemouth bass (*Micropterus salmoides floridanus*) has received considerable attention from fishery biologists and fishermen due to its superior growth potential (Chew 1975). Indistinct and/or missing annuli, however, have precluded the use of scales for age determinations of largemouth bass in Florida. Consequently, there is a paucity of information on age, growth, and mortality rates of Florida largemouth bass in its native range. This type of information is becoming increasingly more important to fishery managers who must evaluate population trends in light of increasing fishing pressure and declining habitat and design management strategies to overcome these problems.

Researchers have used otoliths successfully to age northern largemouth bass (*Micropterus salmoides salmoides*) in thermally enriched environments in Illinois (Taubert and Tranquilli 1982, Perry and Tranquilli 1984), and they have investigated the use of otoliths in ageing largemouth bass in the sub-tropical climate of Florida. Three independent studies determined that ageing Florida largemouth bass using otoliths is a valid method (Taubert and Tranquilli 1982, Coleman et al. 1984, Hoyer et al. 1985).

This study was conducted to provide baseline information on age structure, growth and mortality rates of largemouth bass in major Florida resources.

## Methods

We electrofished in lakes George, Poinsett, Washington and Sawgrass, and Weir several times during October and November 1982 to obtain largemouth bass otolith samples (Table 1). To ensure an adequate sample size for the main age groups in each population and to avoid sacrificing too many fish, we tried to collect 5 largemouth bass per 2.5 cm group from 140 to 241 mm; 10 bass per 2.5 cm group from 242 to 520 mm; and approximately 10 bass ≥521 mm. Additional largemouth bass were sampled, measured, and released between October 1982 and March 1983 to obtain length frequency data from these lakes. We derived age structure data for each population using both otolith and length frequency samples. Age composition of each size group (2.5 cm) was determined for the otolith samples. These data were expanded into the length frequency data to estimate the percent that each age group comprised within the population.

We collected largemouth bass by electrofishing at random from Suwannee River in October and November 1983 and from Lake Kissimmee in February and March 1984 to obtain otoliths for growth estimates. Also, size selected samples were collected from the larger size-groups of largemouth bass from Suwannee River (320 to 640 mm) and Lake Kissimmee (393 to 616 mm) for better representation of the older age groups for the age composition data. Age composition was determined as described above by expanding age data from otolith samples into length frequency distributions.

In the laboratory, fish were measured (total length, TL, mm), weighed (g) and sexed, and the largest of 3 pair of otoliths (sagittae) were removed. Otoliths were dried with a paper towel and stored in labelled vials.

To view annuli, transverse thin sections of otoliths (Beamish 1979) were ob-

**Table 1.** Study area size and the number of Florida largemouth bass collected for age samples and length frequency samples.

| | | Sample size | |
|---|---|---|---|
| Study area | Size | Age | Length frequency |
| George | 18,571 ha | 149 | 1,024 |
| Poinsett | 1,750 ha | 142 | 974 |
| Washington/Sawgrass | 1,925 ha | 140 | 592 |
| Weir | 2,295 ha | 140 | 2,367 |
| Suwannee | 395 km | 289 | 1,105 |
| Kissimmee | 17,763 ha | 230 | 1,070 |

tained using grinding techniques. Otoliths were first ground from the anterior end to the nucleus using No. 120 grit sandpaper on a sanding disc driven by a 1/15 hp electric motor. Grinding speed was controlled by a foot-operated switch to allow greater precision in grinding. After mounting the ground surface to a microscope slide with thermoplastic cement, we ground the posterior portion of the otolith close to the nucleus using the sanding disc. Final sanding and polishing were accomplished by hand using fine sandpaper varying from No. 220 to No. 600 grit. We covered otolith sections with immersion oil to clarify annuli and viewed them with transmitted light at magnification of 25× to 100×. Compressed, darkened rings (formed during periods of slow growth) were defined as annuli (Perry and Tranquilli 1984).

The mounted sections were viewed with a Bausch and Lomb Tri-simplex microprojector using the high position and 5× objective (total magnification 21.3×) so the otoliths could be measured. The otolith radius is not a straight line from the nucleus to the dorsal surface, so measurements were made between each annulus and accumulative measurements were used as the radius (Taubert and Tranquilli 1982). We used a sonic digitizer (Grafbar, Model GP-7, Science Accessories Corp.) and Zenith 100 microcomputer to measure otolith sections and back-calculate mean lengths at annuli. A computer program utilizing the Fraser-Lee method was adapted from Frie (1982). Regression of total fish length against otolith radius was determined from logarithmically (base 10) transformed data.

Total annual mortality ($A$) was calculated from catch curves as described by Everhart et al. (1975) where $A = 1 - e^{-z}$. The instantaneous mortality ($Z$) is estimated from the downward slope of the catch curve.

## Results and Discussion

### Age Composition

Most largemouth bass sampled in Florida were less than 4 or 5 years old; however, bass 6 to 8 years old were commonly collected and fish up to 12 years of age were sampled (Table 2). The 4 youngest age groups comprised 83% to 95% of these populations.

Variation in year class strengths were evident in all largemouth bass populations sampled; however, no major trends were obvious from all bodies of water (Table 2). Regional climatic conditions may influence spawning activities (Chew 1974, Summerfelt 1975), but the absence of trends in year class abundance from all study areas suggests that more localized variables (e.g. local weather, water levels, and predation) dictate year class strengths within a body of water.

An extremely large 1978 year class of largemouth bass was produced in Lake Kissimmee as a result of a planned lake drawdown by the Florida Game and Fresh Water Fish Commission (FGFWFC). This year class comprised 54% of size-selected samples collected monthly from July 1981 to June 1982 in an earlier study (Coleman et al. 1984). Largemouth bass samples collected during February and March 1984 in this study indicated that the 1978 year class ranged from 304 to 576

**Table 2.** Relative year class strengths (percent) of Florida largemouth bass populations sampled from 1982 to 1984.

| Year class | George (fall 82) | Poinsett (fall 82) | Washington & Sawgrass (fall 82) | Weir (fall 82) | Suwannee (fall 83) | Kissimmee (spring 84) |
|---|---|---|---|---|---|---|
| 1983 | | | | | 6.2 | 23.2 |
| 1982 | 23.5 | 16.3 | 44.9 | 17.9 | 44.4 | 15.1 |
| 1981 | 32.0 | 51.0 | 15.6 | 22.5 | 21.3 | 26.3 |
| 1980 | 26.8 | 10.9 | 29.9 | 25.3 | 11.0 | 20.3 |
| 1979 | 4.8 | 8.0 | 4.4 | 20.5 | 7.1 | 2.8 |
| 1978 | 6.2 | 9.6 | 2.2 | 6.7 | 2.0 | 10.2 |
| 1977 | 4.3 | 1.6 | 1.4 | 5.2 | 3.6 | 0.0 |
| 1976 | 0.5 | 1.0 | 1.2 | 1.1 | 2.9 | 0.4 |
| 1975 | 1.8 | 1.0 | 0.2 | 0.3 | 0.8 | 1.1 |
| 1974 | 0.2 | 0.2 | 0.0 | 0.2 | 0.2 | 0.2 |
| 1973 | | | 0.2 | 0.1 | 0.3 | 0.3 |
| 1972 | | | | 0.2 | 0.1 | |
| 1971 | | | | 0.0 | 0.1 | |
| 1970 | | | | 0.1 | | |

mm TL and comprised 10.2% of the population at age 6. The large 1978 year class was attributed not only to water level fluctuation but to improved spawning and nursery habitat as a result of the drawdown (Williams et al. 1979).

Longevity of female largemouth bass appears to be greater than that of males. The oldest age group for females was consistently older than that of males for each population sampled. Male specimens were collected up to 10 years of age in this study, while the oldest females were 12 years old. These results agree with those of Padfield (1951) who found greater numbers of females present in older age groups of largemouth bass in Lake Auburn, Alabama, and Silver Lake, Georgia.

### Mortality Rates

Ages 2 to 5 or 2 to 6 were used to calculate total annual mortality (A) of largemouth bass populations in this study. Ages 0–1 were disregarded because these age groups have not fully recruited into the sportfishery. Older age groups were not used because they were poorly represented in the samples. Mortality estimates were not included for Lake Kissimmee largemouth bass due to excessive year-class fluctuations from 1977–1980 which would violate assumptions for using the catch curve mortality estimate. Annual mortality estimates for Florida largemouth bass populations ranged from 0.30 in Lake Dora (Johnson 1983) to 0.54 in Lake Weir and are within the range reported from other geographical areas (Table 3).

### Growth

Coefficients of determination ($R^2$) ranging from 0.84 to 0.95 indicate a strong linear relationship between log fish total length and log otolith radius for all populations sampled (Table 4).

To test the accuracy of the back-calculation method used in this study, we

**Table 3.** Total annual mortality ($A$) and rates of exploitation ($\mu$) for largemouth bass in Florida and other waters.

| Study area | Total annual mortality ($A$) | Rates of exploitation ($\mu$) | Reference |
|---|---|---|---|
| Lake Weir, Fla. | 0.54 | — | Present study |
| Lake George, Fla. | 0.41 | — | Present study |
| Lake Poinsett, Fla. | 0.42 | — | Present study |
| Lake Washington & Sawgrass, Fla. | 0.53 | — | Present study |
| Suwannee River, Fla. | 0.37 | — | Present study |
| Lake Dora, Fla. | 0.30 | — | Johnson 1983 |
| Ocmulgee River, Ga. | 0.32 | 0.10 | Coomer and Holder 1980 |
| Lake Tobesofekee, Ga. | 0.91 | 0.56 | Ager 1978 |
| Clear Lake, Calif. | 0.56 | 0.20 | Kimsey 1957 |
| Merle Collins Res., Calif. | 0.71–0.92 | 0.36–0.65 | Rawstron and Hashagen 1972 |
| Sutherland Res., Calif. | 0.23–0.91 | 0.18–0.48 | La Faunce et al. 1964 |
| Brown's Lake, Wisc. | 0.24 | 0.12 | Mraz and Threinen 1957 |
| Gladstone Lake, Minn. | 0.62 | 0.15 | Maloney et al. 1962 |
| Sugarloaf Lake, Minn. | 0.70 | 0.35 | Cooper and Latta 1954[a] |
| Whitmore Lake, Minn. | 0.42 | 0.22 | Cooper and Schafer 1954[a] |

[a]Cited from Latta (1975).

**Table 4.** Parameters of double-$\log_{10}$ regressions of otolith radius on fish total length for Florida largemouth bass. Regression parameters are: $N$ = number; $S$ = slope; $I$ = intercept; $R^2$ = coefficient of determination.

| Lake or river | Sex | $N$ | $S$ | $I$ | $R^2$ |
|---|---|---|---|---|---|
| George | Males | 48 | 1.16 | 4.82 | 0.89 |
| | Females | 100 | 1.26 | 4.22 | 0.93 |
| Poinsett | Males | 43 | 1.18 | 4.79 | 0.91 |
| | Females | 94 | 1.22 | 4.83 | 0.95 |
| Washington & Sawgrass | Males | 44 | 1.18 | 4.78 | 0.89 |
| | Females | 95 | 1.27 | 4.73 | 0.92 |
| Weir | Males | 49 | 1.10 | 4.63 | 0.91 |
| | Females | 88 | 1.28 | 4.15 | 0.94 |
| Suwannee | Males | 113 | 1.26 | 4.10 | 0.92 |
| | Females | 165 | 1.29 | 4.00 | 0.94 |
| Kissimmee | Males | 118 | 1.13 | 4.84 | 0.84 |
| | Females | 105 | 1.36 | 3.87 | 0.95 |

compared back-calculated lengths at annuli from 1984 Lake Kissimmee samples to age-specific lengths for largemouth bass measured and aged in 1982. An adequate sample size was available for the 1978 and 1980 year classes for these comparisons. Age-specific lengths of bass collected from March, April, and May 1982 were used since this was the period when the newly formed 1982 annulus was at or near the edge of the otolith. Back-calculated mean lengths from samples collected in 1984 compared very well with mean lengths for these age groups measured March through May 1982. T-tests indicated there was no significant difference ($P \leq 0.05$) between the back-calculated and measured lengths.

Our data indicated substantial differences in growth between male and female largemouth bass, and that size-selecting larger fish in the samples (to better represent older age groups) resulted in a preponderance of females. Therefore, to avoid biased population growth estimates (i.e. bias towards faster growing females), male and female largemouth bass growth rates were calculated separately.

Fishermen and fishery biologists have long noted that larger largemouth bass are usually females. Mean total lengths of male largemouth bass were similar to or only slightly smaller than that of females at age 1 in this study, but differential growth between sexes became obvious by age 2 (Table 5). Growth in length of male largemouth bass appears to slow by age 2 in most systems and their inherent growth capacity is much lower than that of females. Male largemouth bass seldom exceeded 46 cm TL, while females were collected up to 64 cm TL.

Fastest growth rates in this study were seen for largemouth bass populations in the St. Johns River system: lakes Poinsett, George, Washington, and Sawgrass (Table 5). Lake Poinsett largemouth bass had the fastest growth of all study populations. Lake Weir and Suwannee River populations had comparatively slow growth with Suwannee River largemouth bass exhibiting the smallest back-calculated mean lengths at age. Growth rates of largemouth bass from Lake Kissimmee were intermediate.

One important consideration for fishery managers is the age at which a fish enters the fishery. The Florida Game and Fresh Water Fish Commission considers a harvestable-size bass to be >242 mm. Both back-calculated lengths (Table 5) and empirical lengths measured at the time of sampling indicates that Florida largemouth bass typically reach this harvestable size during age 1 + (in their second year of life). However, slower growing fish do not recruit into the sportfishery until age 2 or older. Some slow growing males may not reach harvestable size until age 3, especially in slower growing populations as in the Suwannee River.

Another important consideration for fishery managers in Florida is the time required for a largemouth bass to attain trophy size. The FGFWFC citation program considered a trophy largemouth bass to be >3.63 kg (8 pounds) during the period from 1976 to 1985. Data from our study indicated bass >3.63 kg ranged in length from 567 to 644 mm and in age from 6 to 12 years old. There were several largemouth bass that weighed less than 3.63 kg that were 10 to 12 years old which suggests that slow growing individuals will never attain trophy size. Obviously, almost every trophy size fish will be a female. Also length frequency distributions illustrated that only a small percentage of the largemouth bass in Florida waters are within trophy size.

Since it apparently takes 6 to 12 years to reach trophy size and the percentage of these fish is small, the steady increase in fishing pressure has concerned fishery managers and fishermen about potential overexploitation. Although our total annual mortality estimates do not appear to be excessive compared to mortalities reported

**Table 5.** Mean back-calculated total lengths (mm) at age for male (M) and female (F) largemouth bass collected from Florida waters, 1982 to 1984.

| Study area | Sex | No. in sample | Age 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| George | M | 48 | 176 | 266 | 314 | 337 | 378[c] | 416[a] | 435 | | | | | |
| | F | 100 | 189 | 301 | 368 | 424 | 471 | 507[c] | 523 | 566[c] | | | | |
| Poinsett | M | 43 | 179 | 281 | 322 | 351 | 403[b] | 441[b] | | | | | | |
| | F | 94 | 203 | 317 | 381 | 430 | 495 | 528 | 570[b] | 594[b] | | | | |
| Washington & | M | 45 | 171 | 267 | 333 | 354 | 380 | | | | | | | |
| Sawgrass | F | 96 | 182 | 290 | 370 | 431 | 493[c] | 536 | 555[b] | 545[a] | 568[b] | | | |
| Weir | M | 49 | 169 | 262 | 305 | 334 | 358 | 371[b] | 403[b] | 439[c] | | | | |
| | F | 88 | 169 | 270 | 334 | 388 | 437 | 482 | 491[a] | 522[c] | 567[b] | 568[b] | 584[b] | |
| Suwannee | M | 113 | 148 | 240 | 292 | 328 | 356[c] | 381 | 389 | | | | | |
| | F | 165 | 151 | 252 | 325 | 373 | 414 | 456 | 494 | 536 | 543[a] | 561[a] | 588[a] | 616[b] |
| Kissimmee | M | 118 | 176 | 265 | 309 | 331 | 364 | 412 | 435[a] | | | | | |
| | F | 105 | 178 | 283 | 355 | 413 | 473[b] | 514 | 548[a] | 582[b] | 547 | 586 | | |
| Mean of means | M | 416 | 170 | 264 | 313 | 339 | 373 | 404 | 416 | | | | | |
| | F | 648 | 179 | 286 | 356 | 410 | 464 | 504 | 530 | 558 | 556 | 572 | 586 | 616 |

[a]0 fish sampled for this age.
[b]1 fish sampled for this age.
[c]2 fish sampled for this age.

from other areas (Table 3), selective harvest of larger bass has been documented on several large lakes in Florida (FGFWFC unpubl. data). Due to slow replacement of this resource, restrictive harvest regulations in the form of high slot size limits (e.g. 356 to 508 mm protected size range) are currently being tested by FGFWFC biologists to reduce exploitation.

Carlander (1977) provides an extensive summary of back-calculated lengths of largemouth bass. He concludes that growth is generally slower in the north and more rapid in the south, but points out that variations in each region are great. Mean back-calculated lengths at age in this study suggests that growth of Florida largemouth bass exceeded that of many northern populations, but were frequently surpassed by other southeastern populations and several populations in California. There were many exceptions to these, however, due to the wide range of growth in both our study populations and those in other geographical areas. This illustrates the tremendous influence of environmental factors on fish growth rates despite any inherent growth potential.

Fishery biologists from many states have evaluated stocking of Florida largemouth bass outside of its natural range due to the trophy size it reaches. Comparative growth studies conducted on the early age groups showed similar growth for both subspecies or faster growth for the northern subspecies of largemouth bass (Sasaki 1961, Zolczynski and Davies 1976). Subsequent studies determined that the Florida subspecies grew faster than the northern largemouth bass at older ages in Texas (Inman et al. 1977), California (Bottroff and Lembeck 1978), and Oklahoma (Wright and Wigtil 1980, Mauck 1984). Florida largemouth bass also tended to increase in weight faster than northern largemouth bass and were often heavier at comparable lengths (Chew 1975, Inman et al. 1977). Childers (1975) and Philipp et al. (1981), however, have emphasized the potential for introducing maladaptive genes into northern populations by stocking the Florida subspecies. Therefore, fishery managers need to carefully consider genetic principles when evaluating the introduction of Florida largemouth bass into their state.

## Literature Cited

Ager, L. M. 1978. Exploitation and mortality of largemouth bass in Lake Tobesofkee, Georgia. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 32:429–436.

Beamish, R. J. 1979. Differences in the age of Pacific hake (*Merluccius productus*) using whole otoliths and sectioned otoliths. J. Fish. Res. Board Can. 36:141–151.

Bottroff, L. J. and M. E. Lembeck. 1978. Fishery trends in reservoirs of San Diego County, California, following the introduction of Florida largemouth bass, *Micropterus salmoides floridanus*. Calif. Fish and Game 64:4–23.

Carlander, K. D. 1977. Handbook of freshwater fishery biology. Vol. 2. Iowa State Univ. Press, Ames. 431pp.

Chew, R. L. 1974. Early life history of Florida largemouth bass. Fish Bul. No. 7, Fla. Game and Fresh Water Fish Comm., Tallahassee. 76pp.

———. 1975. The Florida largemouth bass. Pages 450–458 *in* H. E. Clepper and R. H.

Stroud, eds. Black bass biology and management. Sport Fishing Inst., Washington, D.C.

Childers, W. F. 1975. Bass genetics as applied to culture and management. Pages 362–372 *in* H. E. Clepper and R. H. Stroud, eds. Black bass biology and management. Sport Fishing Inst., Washington, D.C.

Coleman, W. S., S. Crawford, and W. Porak. 1984. Largemouth Bass Investigations. D-J Fed. Aid Proj. F-24. Comp. Rep., Fla. Game and Fresh Water Fish Comm., Tallahassee. 95pp.

Coomer, C. E., Jr. and D. R. Holder. 1980. Largemouth bass exploitation in the Ocmulgee River. D-J Fed. Aid Proj. F-29. South Cent. Reg. Fish. Invest., Ga. Dep. Nat. Resourc., Atlanta. 56pp.

Cooper, G. P. and W. C. Latta. 1954. Further studies on the fish population and exploitation by angling in Sugarloaf Lake, Washtenaw County, Michigan. Pap. Mich. Acad. Sci. Arts Lett. 39:209–223.

———. and R. N. Schafer. 1954. Studies on the population of legal-size fish in Whitmore Lake, Washtenaw and Livingston Counties, Michigan. Trans. North Am. Wildl. Nat. Resourc. Conf. 19:239–259.

Everhart, W. H., A. W. Eipper, and W. D. Youngs. 1975. Principles of Fishery Science. Cornell Univ. Press, Ithaca, N.Y. 278pp.

Frie, R. V. 1982. Measurement of fish scales and back calculation of body lengths using a digitizing pad and micro-computer. Fisheries. 7(6):5–8.

Hoyer, M. V., J. V. Shireman, and M. J. Maceina. 1985. Use of otoliths to determine age and growth of largemouth bass in Florida. Trans. Am. Fish. Soc. 114:307–309.

Inman, C. R., R. C. Dewey, and P. P. Durocher. 1977. Growth comparisons and catchability of three largemouth bass strains. Fisheries. 2(5):20–25.

Johnson, W. E. 1983. Investigations of year-class strength of largemouth bass in the Oklawaha chain of lakes. D-J Fed. Aid Proj. F-30. Oklawaha Basin Fish. Invest., Fla. Game and Fresh Water Fish Comm., Tallahassee. 62pp.

Kimsey, J. B. 1957. Largemouth bass tagging at Clear Lake, Lake County, California. Calif. Fish and Game. 43:111–118.

LaFaunce, D. A., J. B. Kimsey, and H. K. Chadwick. 1964. The fishery at Sutherland Reservoir, San Diego County, California. Calif. Fish and Game. 50:271–291.

Latta, W. C. 1975. Dynamics of bass in large natural lakes. Pages 175–182 *in* H. E. Clepper and R. H. Stroud, eds. Black bass biology and management. Sport Fishing Inst., Washington, D.C.

Maloney, J. E., D. R. Schupp, and W. J. Skidmore. 1962. Largemouth bass population and harvest, Gladstone Lake, Crow Wing County, Minnesota. Trans. Am. Fish. Soc. 91:42–52.

Mauck, P. E. 1984. Largemouth Bass Investigations. D-J Fed. Aid Proj. F-39-R Comp. Rep., Okla. Dep. Wildl. Conserv., Oklahoma City. 29pp.

Mraz, D. and C. W. Threinen. 1957. Angler's harvest, growth rate and population estimate of the largemouth bass of Browns Lake, Wisconsin. Trans. Am. Fish. Soc. 85:241–256.

Padfield, J. H. 1951. Age and growth differentiation between the sexes of the largemouth bass, *Micropterus salmoides* (Lacepede). J. Tenn. Acad. Sci. 26:42–54.

Perry, L. G. and J. A. Tranquilli. 1984. Age and growth of largemouth bass in a thermally altered reservoir, as determined from otoliths. North Am. J. Fish Manage. 4:321–330.

Philipp, D. P., W. F. Childers, and G. S. Whitt. 1981. Management implications for different genetic stocks of largemouth bass (*Micropterus salmoides*) in the United States. Can. J. Fish. Aquat. Sci. 38:1715–1723.

Rawstron, R. R. and K. A. Hashagen, Jr. 1972. Mortality and survival rates of tagged largemouth bass (*Micropterus salmoides*) at Merle Collins Reservoir. Calif. Fish and Game. 58:221–230.

Sasaki, S. 1961. Introduction of Florida largemouth bass into San Diego County. Inland Fish. Adm. Rep. No. 61–11. (Mimeo). Calif. Dep. Fish and Game. Sacramento, 6pp.

Summerfelt, R. C. 1975. Relationship between weather and year-class strength of largemouth bass. Pages 166–174 *in* H. E. Clepper and R. H. Stroud, eds. Black bass biology and management. Sport Fishing Inst., Washington, D.C.

Taubert, B. D. and J. A. Tranquilli. 1982. Verification of the formation of annuli in otoliths of largemouth bass. Trans. Am. Fish. Soc. 111:531–534.

Williams, V., E. Moyer, and M. Hulon. 1979. Water level manipulations. D-J Fed. Aid Proj. F-29 Comp. Rep., Fla. Game and Fresh Water Fish Comm., Tallahassee. 23pp.

Wright, G. L. and G. W. Wigtil. 1980. Comparison of growth, survival, and catchability of Florida, northern, and hybrid largemouth bass in a new Oklahoma Reservoir. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 34:31–38.

Zolczynski, S. J., Jr., and W. D. Davies. 1976. Growth characteristics of the northern and Florida subspecies of largemouth bass and their hybrid, and a comparison of catchability between the subspecies. Trans. Am. Fish. Soc. 105:240–243.