Effects of Dam Removal on Dead Lake, Chipola River, Florida

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Abstract: Removal of Dead Lake Dam in December 1987 reduced low pool elevation an additional 1.3 m, resulting in approximately 85 percent bottom exposure. Increased fluctuation provided short-term benefits to the sport fish community in the form of strong largemouth bass (*Micropterus salmoides*) year classes and improved water quality. Percent composition of dominant sport fish changed little after dam removal, but total fish species observed increased from 34 to 61 after dam removal. Increased elevation in the Apalachicola River resulted in reduced flow and depressed dissolved oxygen levels in Dead Lake. Striped bass (*Morone saxatilis*) have been observed in limited numbers above Dead Lake since removal of the dam.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:512–523

Dead Lake is a shallow, natural, wide reach of the Chipola River, Florida. In 1960, a 240-m interlocking sheetpile coffer dam was installed across a narrowing of the Chipola River, near Wewahitchka, Florida. Its primary function was to maintain the highest water possible during periods of extended drought but still allowed for some climatic water level fluctuations.

Sport fishing was excellent immediately following dam construction, particularly during spawning season, but declined appreciably by the late 1970s (Young and Crew 1982). Aquatic plants, notably Brazilian elodea (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*) grew rapidly and hindered angler access (Banks et al. 1984). In an attempt to control nuisance vegetation, 4 vertical lift gates were installed adjacent to the dam in July 1974 to lower water levels further for planned drawdowns. Attempts to conduct drawdowns for 4 consecutive years (1974–1977) failed because of inadequate structure design and opposing high water in the Apalachicola River. Because improvements in sport fishing were less than expected, the Dead Lake Dam was removed in December 1987 in response to public demand. Initially, only the sheetpile portion of the dam was removed. Granite rocks used to brace the downstream side of the sheetpile were left in place and hindered river flow, fish passage, and navigation during low water. In February 1989, the rocks obstructing the channel were removed, restoring the natural flow of the old river channel.

The objectives of this study were to evaluate the effects of dam removal on the Dead Lake sport fish community and to determine if striped bass would return to thermal refugia historically utilized in the upper Chipola River.

This study was funded by Federal Aid in Sport Fish Restoration, Project No. F-39. We thank Lothian Ager for contributing to the original study design and Charles Mesing for guiding the project and editorial comments. Bob Rousseau, Mike Spelman, and Roy Land helped collect data. The U.S. Geological Survey (USGS) and the U.S. Army Corps of Engineers (COE) assisted in stage readings for the Dead Lake and Apalachicola River, respectively. Mr. Bill Camp and Wildlife Officer Robert Miller kept weekly records of the Dead Lake water level gauge after the USGS gauge was removed.

Methods

Dead Lake is located in the Florida panhandle (Calhoun and Gulf counties) and can be described as a cypress swamp in a wide part of the Chipola River floodplain. It is 14.5 km long and has a surface area of 2,700 ha at full pool. The Chipola River is 134.9 km long, lies entirely in Florida, and drains approximately 3,124 km^2 of forested and agricultural floodplain. The upper Chipola River is spring-fed, clear, and relatively hard (range: 35–123 mg/liter expressed as $CaCO_3$) with a pH range of 6.2–8.0. Water in Dead Lake is more turbid and softer (range: 32–99), tannin-stained and slightly more acidic (range: 6.0–7.7) than the upper river (Ager and Land 1984).

The Chipola River is the largest tributary to the Apalachicola River. Approximately 21 km upstream from the confluence of the Chipola River with the Apalachicola River, a short (5 km) natural distributary, the Chipola Cutoff, flows from the Apalachicola River and merges with the Chipola River 0.8 km below the Dead Lake forming Cutoff Island (Fig. 1). A considerable volume of Apalachicola River water is diverted through the Chipola Cutoff and acts as a "water-dam" on the Chipola River directly affecting the water levels in Dead Lake (Banks et al. 1984).

Surface areas of Dead Lake were calculated by the Northwest Florida Water Management District (NWFWMD) using a curvilinear area-elevation graph for water levels from 4.0 to 6.7 m Mean Sea Level (MSL). Estimates of surface areas below 4.0 m MSL were determined by extrapolating the relationship to 3.0 m MSL (the lowest level observed during the study). The USGS provided mean daily gauge height readings from November 1979 to September 1984 and February 1988 to December 1990. Missing water level data (October 1984 to

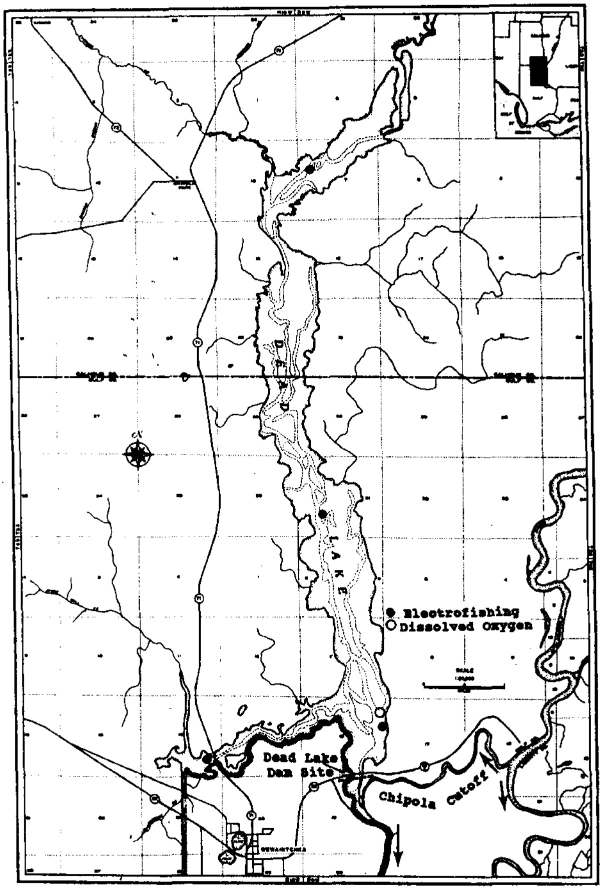

Figure 1. Location of electrofishing sites, dissolved oxygen profile site, relationship of Chipola Cutoff (Apalachicola River) to Dead Lake outflow and study area.

January 1988) were predicted using a linear regression (r^2 = 0.89) of the Dead Lake Dam gauge against the Apalachicola River gauge readings at Blountstown, Florida, from the day before. Volunteers provided water level readings from January 1991 to December 1992.

In 1984, 4 fixed electrofishing sites adjacent to the main river channel were established in Dead Lake to collect baseline fish population data in anticipation of dam removal (Fig. 1). Habitat types were similar among these sites, but sites differed in proximity to the river channel, water depth and flow rates. Sample sites included spatterdock (*Nuphar luteum*), the dominant plant in Dead Lake prior to the dam removal, and the submerged river levee which was thickly lined with bald cypress (*Taxodium distichum*) trees and knees.

Electrofishing samples were conducted from May 1984 to December 1992 using a Smith-Root (GPP 5.0) electrofisher. Electrofishing was conducted along the river channel and in the flooded timberlands behind or near the backside of the natural river levee where boat access was feasible. Samples were collected during daylight hours for 10 minutes of pedal time. All sport fish species were individually weighed (g), measured (mm), and sorted into 2-cm size classes. Data are reported as number of fish per sample. Otoliths were removed from a representative sample of largemouth bass (at least 10 fish per 2-cm size class) for age analysis and year class strength determination. Length-frequency distributions for largemouth bass for 1990 and 1991 were determined from the 4 fixed sites plus 10 supplemental sites taken in the fall of each year. Additional largemouth bass collected randomly from throughout Dead Lake in January 1992 were combined with the fall 1991 length-frequency data to increase sample size under the assumption that negligible growth (<2 cm) occurred between sampling periods.

To assess trends in sport fish abundance, total number of sport fish collected at all sample sites was regressed against time (months since study inception). Multiple regression was used to account for confounding effects of water level on electrofishing efficiency. All statistical differences were declared significant at $\alpha \leq 0.05$.

Two 0.4-ha rotenone blocknet samples were set in 1992 near historic sample sites (Young and Crew 1982) to augment the electrofishing area. Fish were collected for 3 days.

Dissolved oxygen (DO) profiles were taken during summers of 1984–1992 to investigate oxygen stratification using a YSI Model 54A meter. DO stratification was loosely defined as a sharp decline in DO values in relation to depth irrespective of evidence of a thermocline. All DO profiles were taken at 1 m intervals from surface to bottom in the deepest area of Dead Lake, near the dam (Fig. 1). Additional DO measurements were taken throughout the Chipola River and Dead Lake after the dam was removed to determine the distribution or existence of depressed oxygen levels.

From 1989 to 1992, striped bass thermal refugia (springs and cool water creeks) were surveyed in the upper Chipola River (Barkuloo 1967). Divers positioned themselves at the spring entrance within the clear water plume and counted all visible striped bass during a 15-minute period. Annual thermal refugia surveys were summarized and average number of striped bass per drive calculated. During 1991, paired divers drifted underwater in the river channel to count striped bass not using thermal refugia. Additionally, the upper Chipola River channel was electrofished during poor visibility to supplement visual surveys.

Results

Water levels fluctuated prior to this dam removal, but water level fluctuation in Dead Lake returned to natural conditions following dam removal (Fig. 2). Removal of the dam reduced the low pool elevation in Dead Lake from a minimum of 4.3 m MSL in November 1981 to 3.0 m MSL in November 1990. The additional decrease of 1.3 m exposed an estimated 1,000 ha of lake bottom

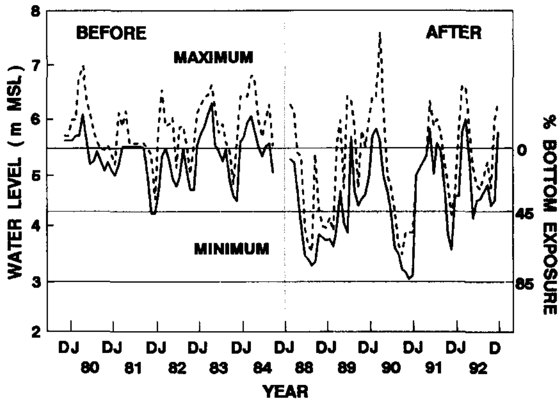

Figure 2. Monthly minimum and maximum water levels (meters MSL) on Dead Lake prior to dam removal, 1980–1984, and following dam removal, 1988–1992, with corresponding percent bottom exposure. Zero percent bottom exposure represents the Dead Lake Dam sill level.

inundated continuously since the installation of the dam in 1960. Water levels below 4.0 m MSL led to an estimated 60–70 percent bottom exposure for 8 months in 1988 and 6 months in 1990 (Fig. 2), with associated bottom habitat improvement through drying, consolidation, and oxidation of organic sediment. The smallest Dead Lake surface area, approximately 400 ha, was estimated at the low pool elevation of 3.0 m MSL with an estimated 85 percent bottom exposure.

Electrofishing catch rates were inversely correlated with water level presumably because fish were confined to the remnant river and side channels (Fig. 3). For example, the greatest number of sport fish was collected in fall 1990 at the lowest water levels during the study (Fig. 4).

Early workers on Dead Lake (Young and Crew 1982) reported standing crop in 1964 at 31.5 kg/ha. Subsequently, block net mean standing crop estimates for 1972, 1973 and 1978 were 65.5, 74.6, and 62.0 kg/ha, respectively (Fig. 5), indicating Dead Lake has long been a low productive water body. However, in 1981, standing crop estimates increased to 111.5 kg/ha (72.5 kg/ha [65%] sport fish). Estimated standing crop in 1992 after the dam removal was 141.0 kg/ha (62.0 kg/ha [44%] sport fish).

Similar to blocknet samples, electrofishing samples indicate sport fish abundance has changed little following dam removal. Electrofishing samples indicate no obvious temporal trend in sport fish abundance (Fig. 4). Regression analysis indicates much of the variability in electrofishing catch rates is due to fluctuation of water level, although a slight but statistically significant downtrend in catch rates over time was observed for total fish (P = 0.03). However, the magnitude of the slope coefficient for time is very small (−0.007), and the biological significance of this trend is minimal. A similar situation was observed for juvenile sport fish and juvenile largemouth bass, with water level a highly significant predictor of catch rates, but no significant time trend (P = 0.06, P = 0.08, respectively).

However, strong largemouth bass year classes were produced in 1989 and 1991 (Fig. 6). These strong year classes were produced after extended low water

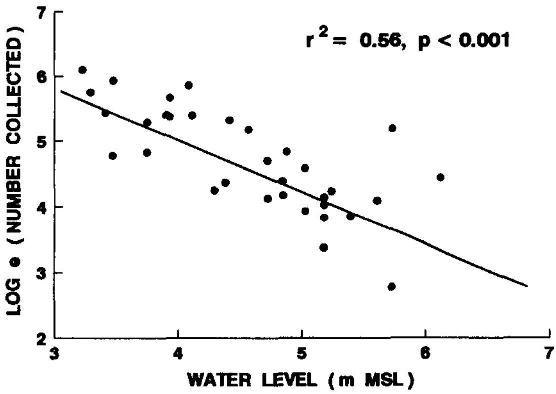

Figure 3. Relationship of water level and total sport fish collected in 10-minute electrofishing samples at 4 sites, Dead Lake, May 1984 to November 1992.

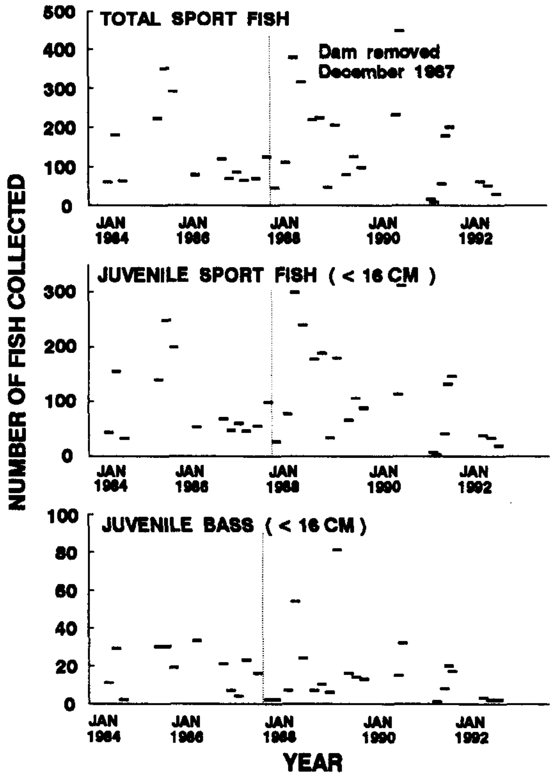

Figure 4. Number of sport fish collected in 10-minute electrofishing samples at 4 sites, Dead Lake, May 1984 to November 1992.

levels during each of the preceding summers followed by sustained high water levels in the upper portion of the lake. Rejuvenated backwater areas were inundated to a depth suitable for spawning. Apparently, the duration of high water was sufficient to enhance survival and recruitment of the 1989 and 1991 year classes.

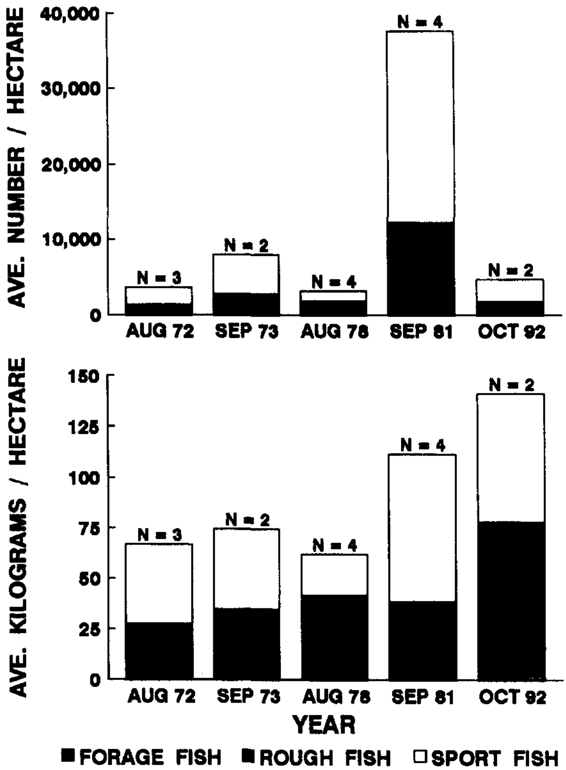

Figure 5. Average standing crop of fish, by category, collected from blocknets (*N*/ha and weight/ha) in Dead Lake during summers of 1972, 1973, 1978, 1981, and 1992.

There was little change in percent composition of dominant sport fish before and after the dam removal (Table 1). However, the number of fish species collected by electrofishing increased from 34 to 61 species after the dam was removed (Hill et al. 1990).

Prior to the dam removal, DO profiles in Dead Lake indicated occasional oxygen stratification during summer months (Fig. 7). No oxygen stratification has been observed in Dead Lake since the dam removal. Ample DO (range: 8.0–8.5 mg/liter) was measured during summer of 1988; however, DO has been marginal (<5 mg/liter) for sport fish on several occasions, notably 1991 (range: 3.9–4.4 mg/liter) when Dead Lake sustained elevated water levels due to extended flooding on the Apalachicola River.

From 1989 through 1992, 13 striped bass thermal refugia in the Chipola River were investigated by divers. An average of 2.0 striped bass/dive and 1.0 striped bass/dive were recorded in 1989 and 1990, respectively. Seventy-six striped bass were observed at 5 springs in 1991 during 24 dives (3.2 fish/dive). During 1992, 95 striped bass were observed during 24 observations (4.0 striped bass/dive).

During 1991, striped bass were not observed outside thermal refugia dur-

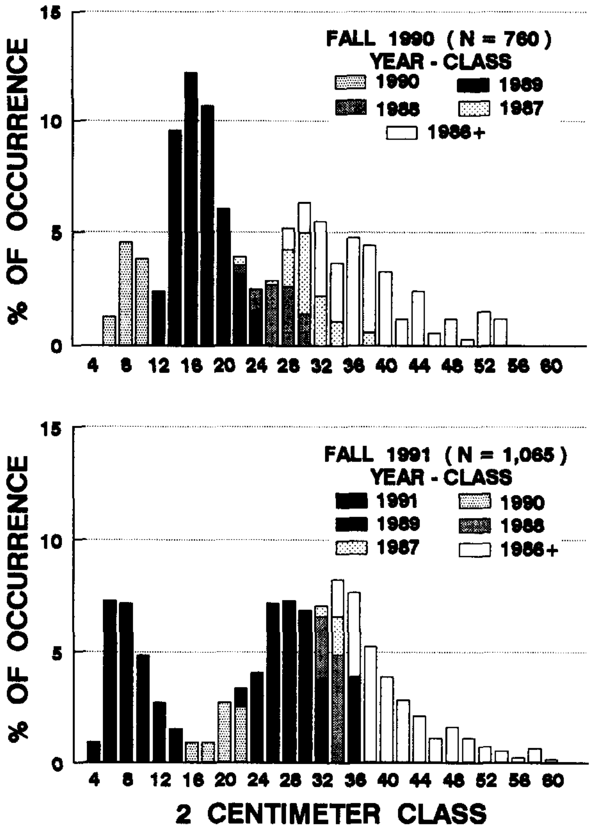

Figure 6. Length-frequency and age distributions of largemouth bass electrofished from Dead Lake during fall 1990 and fall 1991 (combined with January 1992 largemouth bass). The 1986+ group includes all bass from the 1986 and older year-classes.

Table 1. Percent composition (number and weight) of selected sport fish collected by electrofishing on Dead Lake before and after dam removal (1984–1992).

	N		Weight	
	Before	After	Before	After
Largemouth bass	23%	20%	53%	55%
Bluegill	45%	32%	13%	16%
Redear sunfish	12%	16%	16%	13%
Redbreast sunfish	6%	11%	2%	3%
Other sport fish	14%	21%	17%	13%

ing 3 scuba drift efforts totaling 9.2 km. In 1992, only 1 striped bass was collected in more than 10 hours of electrofishing encompassing 45 km in the upper Chipola River channel. In 1993, 18 striped bass were electrofished in the upper Chipola River and thermal refugia after 20 hours of pedal time encompassing 70 km.

Discussion

The principal benefit of dam removal is the increased potential for periodic low water levels (extreme water level fluctuations) and associated improvements in habitat due to drying, compaction, and oxidation of bottom sediments (Pierce et al. 1963, Wegener and Williams 1974, Lambou 1989, Fisher and Zale 1991). After dam removal, improved bottom stability and the establishment of emergent aquatic plants such as giant cutgrass (*Zizaniopsis miliacea*), black willow (*Salix sp.*), and alligatorweed (*Alternanthera philoxeroides*) were observed throughout the lake. Submerged native vegetation has not become established in Dead Lake proper despite extended periods of bottom exposure, probably because of turbidity and regularly fluctuating water levels (Davis and Brinson 1980). However, southern watergrass (*Luziola fluitans*) became established in a substantial portion of a shallower and less turbid major tributary. The abundant emergent vegetation functioned as sport fish nursery areas in absence of submerged vegetation (Martin et al. 1981, Miranda et al. 1984).

Electrofishing and blocknet samples corroborate earlier data that Dead Lake has limited sport fish productivity, but a return to natural water level fluc-

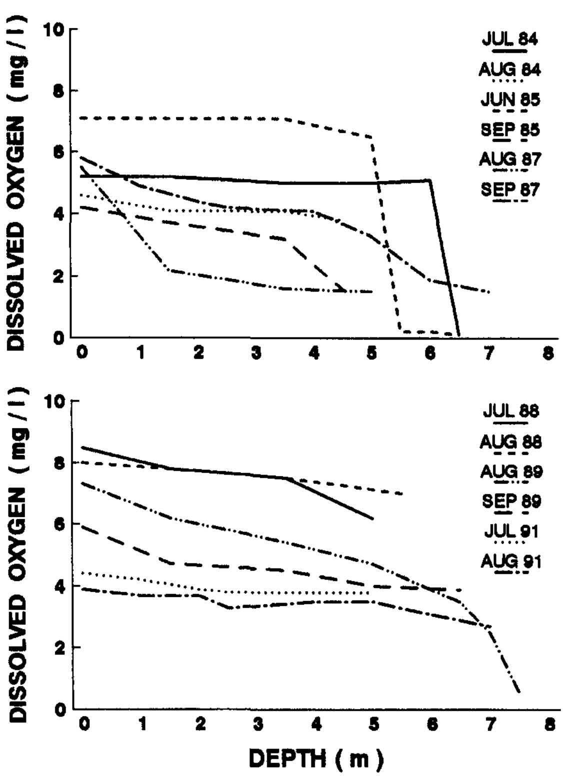

Figure 7. Dissolved oxygen (mg/liter) profiles taken during summers in Dead Lake at the same site prior to dam removal (above) and after dam removal (bottom).

tuations has led to occasional improvements in the sport fish population (Hall and Lambou 1990). For example, extended bottom exposure during low water in 1988 and 1990 led to habitat rejuvenation as evidenced by increased yields from blocknets in 1992. Additionally, high water during and following the spawn in the rejuvenated backwater areas likely resulted in the production of strong year classes of largemouth bass in 1989 and 1991. Lambou (1989) and Plosky (1986) describe the benefits and importance of timing, duration, and lag time of the natural periodic flooding of the river floodplain to the sport fish population.

Low electrofishing catch rates during the summer of 1991 coincided with depressed DO values measured in the lake. Fish probably emigrated from the lake in search of more oxygenated water (Hern et al. 1980).

Although it was not the focal point of this study, the number of fish species collected from electrofishing almost doubled following dam removal, further evidence of improvement in Dead Lake. For example, many new *Notropis* species such as bluenose shiner (*N. welaka*) and ironcolor shiner (*N. chalybaeus*) were encountered within their preferred habitats and larger sport fish (e.g., striped bass and white bass [*M. chrysops*]) were collected after dam removal.

Except for the high standing crop estimate for 1981, blocknets demonstrated the low productivity of the system. The increase in standing crop estimates from blocknets for 1981 can be attributed to the then-prevalent aquatic vegetation (Brazilian elodea) when dominant fish species were juvenile bluegill and blue-spotted sunfish (*Enneacanthus gloriosus*) (Young and Crew 1982).

The unique relationship between water levels in the Apalachicola River and Dead Lake has a significant influence on the rejuvenation of aquatic habitats, sport fish populations and dissolved oxygen levels. The weak year classes of largemouth bass in 1988 and 1990 occurred after a summer of high water in the Apalachicola River and rapidly dropping water levels during the spawning season. A rapid drop in Dead Lake water level following a major flood in the Apalachicola River in March 1990, competition, and perhaps cannibalism from the strong 1989 year class was deleterious to the survival of the 1990 year class (Jenkins 1975). The rapid changes in water level may have affected year class strength of largemouth bass (Heman et al. 1969, Johnson et al. 1981, Ploskey 1986).

The effect of the Apalachicola River on Dead Lake water levels affected the amount of dissolved oxygen in the lake. During summer, when discharges from the Apalachicola River exceed the outflow of Dead Lake, decreased flows occur in the lake as the Chipola River backs up. Lower DO values were measured throughout the lake compared to upstream and downstream of Dead Lake, in 1991. Substrate analysis reported by NWFWMD revealed a high percentage of organic material in Dead Lake (Banks et al. 1984). Depressed DO values, also reported by Ager and Land (1984), were likely the result of high biological oxygen demand from the decomposition of accumulated organic matter in conjunction with reduced flows (Shaw 1983). Sustained improvement in Dead Lake water quality and sport fish habitat may require successive annual summer low water, although predictable strong year classes may not occur annually (von Geldern 1971). Catastrophic floods may also be necessary to assist in the improvement of Dead Lake by scouring away the 27 years of accumulated detritus in the areas never exposed by extreme low water.

As a direct result of the dam removal, anadromous fish, e.g. striped bass, can now travel through Dead Lake to spawn or seek critical thermal refugia in the upper Chipola River. Prior to 1960, records of striped bass in the upper Chipola River were limited to anecdotal evidence. Several YOY striped bass specimens were collected from the Chipola Cutoff in July 1959 and at the Woodruff Dam in August 1959, indicating a successful spawn in the Apalachicola drainage in 1959 (Barkuloo 1970). Aggregates of large striped bass were reportedly seen in the summer, usually in clear springs in the upper river. The dam was listed as a principal fishing spot for striped bass in the spring by Barkuloo (1967). Presumably, these fish were attempting to migrate up the Chipola River to spawn or seek thermal refugia. Reports of striped bass seen or caught in the Chipola River and Dead Lake diminished over time due to the obstruction by the dam. Following dam removal, striped bass returned to the upper Chipola River in limited numbers. The presence of striped bass in the Chipola River above Dead Lake demonstrates that removal of the Dead Lake Dam has increased the potential for restoration of native striped bass in the Apalachicola River.

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