

Food Habits of Bowfin in the Black and Lumber Rivers, North Carolina

Keith W. Ashley, District 4 Fisheries Biologist, North Carolina
Wildlife Resources Commission, Division of Inland Fisheries, 102
Hillcrest Drive, Elizabethtown, NC 28337

Robert T. Rachels, District 4 Assistant Fisheries Biologist, North
Carolina Wildlife Resources Commission, Division of Inland
Fisheries, 315 Old NC 20, St. Pauls, NC 28384

Abstract: We examined food habits of bowfin (*Amia calva*), in the Black and Lumber rivers, North Carolina. Stomachs from 192 Black River bowfin and 175 Lumber River bowfin were analyzed to determine frequency of occurrence and percent by number and weight of individual food items consumed from 1994 to 1997. Crustaceans [primarily crayfish (*Astacidae*) and grass shrimp (*Palaemonidae*)] were the dominant food item consumed by bowfin in both rivers. They occurred, on average, in 79% of Black River bowfin stomachs containing food and accounted for 65% by number and 53% by weight of all food items consumed. In the Lumber River crayfish occurred, on average, in 71% of bowfin stomachs containing food and accounted for 63% by number and 27% by weight of all food items consumed. Fishes, primarily centrarchids and ictalurids, were of secondary importance in the diet of bowfin. Other fish of minor importance included American eel (*Anguilla rostrata*), bowfin, creek chubsucker (*Erimyzon oblongus*), and pirate perch (*Aphredoderus sayanus*).

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The Black and Lumber Rivers are large caostal plain streams located in southeastern North Carolina. These popular fishing streams have traditionally provided excellent fishing for largemouth bass, sunfish (*Lepomis* spp.), catfish (*Ictalurus* spp.), chain pickerel (*Esox niger*), and yellow perch (*Perca flavescens*) (Louder 1963, Nelson and Ashley 1989). The Black River has also been considered one of the premier redbreast sunfish (*L. auritus*) fisheries statewide. The Lumber River has received designation by both Federal and State agencies as a wild and scenic river. A portion of the Black River has been designated Outstanding Resource Waters by the North Carolina Division of Water Quality (DWQ). Both rivers support large numbers of bowfin.

Routine fish tissue sampling by Wildlife Resources Commission and State DWQ personnel in 1995 and 1996 revealed higher than normal levels of mercury in bowfin

collected from selected waters located throughout the Coastal Plain region of the state. This finding prompted the state Health Director to issue a statewide fish consumption advisory on bowfin in June 1997. The advisory recommends consumption of bowfin be restricted to no more than 2 meals per month by the general public and that children, pregnant women, and women of child bearing age do not consume any bowfin.

Bowfin, which tend to bioaccumulate heavy metals such as mercury in their tissues, are top level predators in both rivers. As such, they would be expected to have higher levels of mercury in their tissues than other fish species such as bluegill (*L. macrochirus*). The objectives were to examine the food habits of bowfin in the Black and Lumber rivers and determine frequency of occurrence and percent by number and weight of individual food items consumed by bowfin over a 4-year period (1994–1997).

We thank Dr. K. O'Brien, statistician with the East Carolina University Department of Biostatistics, School of Allied Health Sciences, for his assistance with study design and data analysis.

Methods

Bowfin were collected from the Black and Lumber rivers using boat mounted electrofishing gear (Smith-Root Mark VI GPP). Standardized electrofishing samples were collected from 8 fixed stations on each river from 1 April through 30 September 1994–1997. Electrofishing stations were sampled for 15 minutes, 3–4 times per year (if possible). Only 3 samples were collected from each river in 1996. The September samples were not collected that year due to extremely high water levels resulting from Hurricanes Bertha and Fran.

All bowfin collected were weighed (g) and measured (mm TL). Stomach contents were collected using puled gastric lavage (Foster 1977). Approximately 25% of all fish were sacrificed to verify the effectiveness of the technique. Individual food items were identified, sorted, counted, and weighed (wet weight). Percent frequency occurrence was calculated by dividing the total number of occurrences of food items in a particular food item group by the total number of stomachs containing food for that year. Percent composition (numbers and weights) was calculated by dividing the total number (or weight) of food items in a particular food item group by the total number (or weight) of food items for all food item groups for that year.

Percent frequency occurrence and percent composition data were statistically compared among and between years, by river, using chi-square tests (goodness of fit and Pearson) (Sokal and Rohlf 1981).

Results

Examination of stomachs from sacrificed fish indicated pulsed gastric lavage removed approximately 100% of all food material present. Occasionally, a large particle would become lodged in the esophagus and require removal with forceps. It is an excellent technique for collecting stomach contents without injury to the fish.

Black River

Stomach contents from 192 bowfin were removed and analyzed (Table 1). Forty-seven (24%) of the stomachs were empty. Average total length and weight of these fish were 52 cm (34 cm to 76 cm) and 1.6 kg (0.4 kg to 5.1 kg).

Crustaceans (primarily crayfish) were the dominant food item consumed by Black River bowfin on a percent frequency occurrence basis, occurring on average in 79% of all stomachs containing food (Fig. 1). Fish remains occurred less frequently in the diet, occurring on average in 21% of all stomachs containing food. The occurrence of crustaceans in the Black River bowfin diet was significantly higher ($P < 0.01$) in 1994 than in 1995 but significantly lower in 1995 than in 1997. There was a significantly higher ($P < 0.05$) occurrence of fish remains in the diet in 1995 than in 1997. All other frequency comparisons for each group were not significantly different. Among years, the occurrence of crayfish in the Black River bowfin diet was significantly higher ($P < 0.01$) than the occurrence of fish remains all 4 years of the study.

Crustaceans were also the dominant food item consumed numerically, accounting on average for 65% of all food items consumed by Black River bowfin (Fig. 2). Fish remains accounted, on average, for an additional 8% by number of all food items in the diet. Additionally, grass shrimp occurred in 5% of the stomachs containing food and accounted for 10% by number, but only 1% by weight, of all food items consumed. Numerically, the proportion of crustaceans in the Black River bowfin diet was significantly higher ($P < 0.01$) than that of fish remains all 4 years.

In terms of percent composition by weight, crustaceans were once again the dominant food item, accounting on average for 53% of all food items in the Black River bowfin diet (Fig. 3). However, fish remains comprised a much higher proportion of the diet by weight, accounting for 47% of all food items consumed. The proportion

Table 1. Percentage composition (numbers and weights) of food items in stomachs of bowfin collected from the Black ($N = 146$) and Lumber ($N = 117$) rivers, North Carolina, 1994–1997.

Food Item	Black River		Lumber River	
	%No.	%Wt.	%No.	%Wt.
Astacidae	65	53	63	27
Palaemonidae	10	1	2	<1
Odonata	14	2	2	<1
Insect remains	0	0	1	<1
Centrarchidae remains	5	14	14	36
Ictaluridae remains	1	15	5	14
Osteichthyes				
<i>Anguilla rostrata</i>	2	12	2	4
<i>Amia calva</i>	1	1	1	3
<i>Lepisosteus osseus</i>	<1	<1	0	0
<i>Esox niger</i>	<1	<1	0	0
<i>Erimyzon oblongus</i>	0	0	1	7
<i>Aphredoderus sayanus</i>	1	<1	1	<1
<i>Etheostoma olmstedti</i>	0	0	1	<1
Unidentified fish remains	2	1	9	8
Totals	100	100	100	100

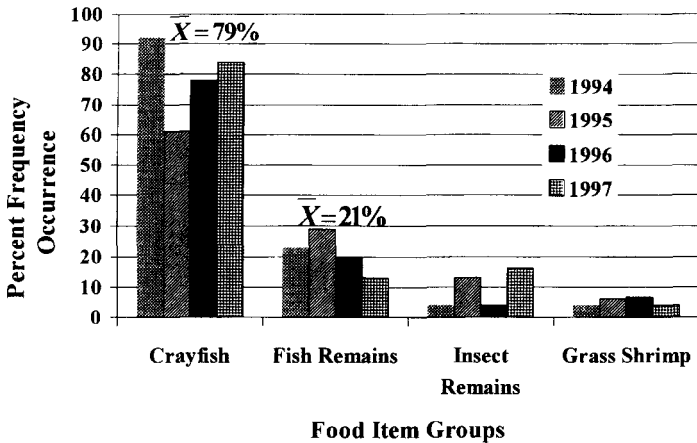


Figure 1. Percent frequency occurrence of major food item groups in bowfin stomachs collected from the Black River, 1994–1997.

of crustaceans by weight in the Black River bowfin diet was not significantly different between 1994 and 1995 ($P > 0.05$). However, significantly lower proportions of crustaceans occurred in the diet between 1994 and 1996 ($P < 0.01$) and 1997 ($P < 0.01$), between 1995 and 1996 ($P < 0.01$) and 1997 ($P < 0.01$), and between 1996 and 1997 ($P < 0.05$).

There was no significant difference in the proportion of fish remains by weight in the diet between 1994 and 1995 ($P < 0.05$). However, there were significantly higher proportions between 1994 and 1996 ($P < 0.01$) and 1997 ($P < 0.01$), between

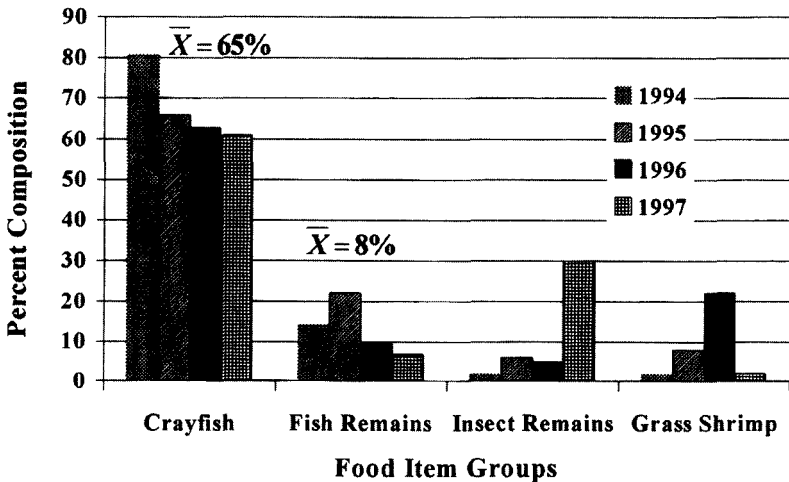


Figure 2. Percent composition (number) of major food item groups in bowfin stomachs collected from the Black River, 1994–1997.

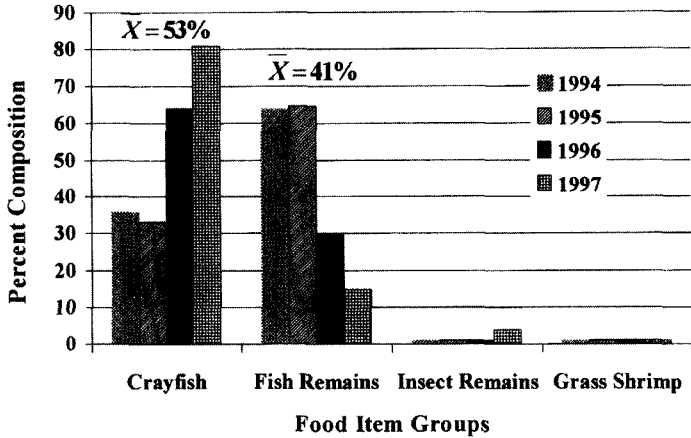


Figure 3. Percent composition (weight) of major food item groups in bowfin stomachs collected from the Black River, 1994–1997.

1995 and 1996 ($P < 0.01$), and 1997 ($P < 0.01$), and between 1996 and 1997 ($P < 0.05$). Among years, the proportion by weight of crustaceans in the Black River bowfin diet in 1994 and 1995 was significantly lower ($P > 0.05$) than the proportion by weight of fish remains. This trend reversed itself in 1996 and 1997 when the proportion by weight of crustaceans in the Black River bowfin diet was significantly higher ($P < 0.01$) than the proportion by weight of fish remains.

The fish remains food item group was comprised primarily of sunfish [bluegill (*L. macrochirus*), warmouth (*L. gulosus*), spotted sunfish (*L. punctatus*), flier (*Cen-*

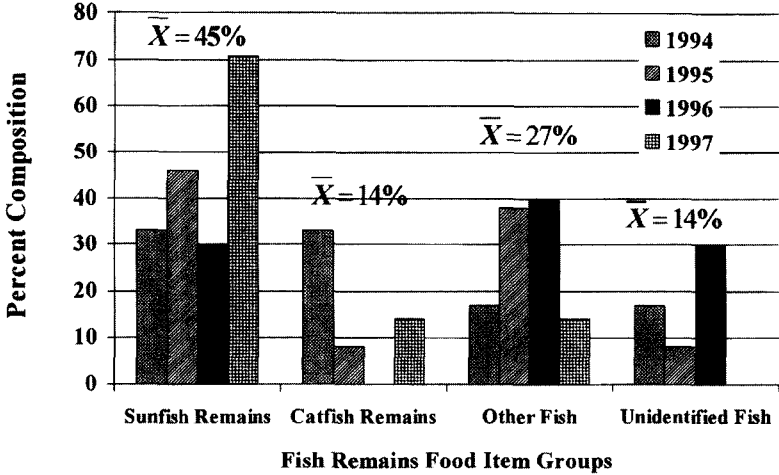


Figure 4. Percent composition (number) of fish remains food item groups in bowfin stomachs collected from the Black River.

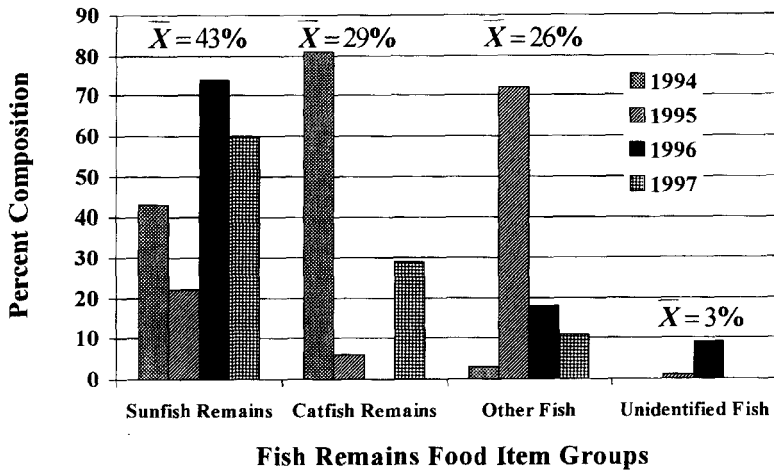


Figure 5. Percent composition (weight) of fish remains food item groups in bowfin stomachs collected from the Black River, 1994–1997.

trachus macropterus), and bluespotted sunfish (*Enneacanthus gloriosus*), catfish [blue (*Ictalurus furcatus*) and flathead], and other fish [primarily American eel (*Anguilla rostrata*), bowfin, and pirate perch (*Aphredoderus sayanus*)] (Table 1). Sunfish dominated this food item group in the Black River bowfin diet, both on a percent composition by number and weight basis (Figs. 4, 5). Numerically, odonates were the second most abundant (14%) food item consumed by Black River bowfin but did not account for a major proportion by weight of food items consumed.

Lumber River

Stomach contents from 175 Lumber River bowfin were removed and analyzed, of which 58 (33%) were empty (Table 1). Average total length and weight of these fish were 54 cm (31 cm to 81 cm) and 1.6 kg (0.2 kg to 5.6 kg).

Crustaceans were also the dominant food item in the diet of Lumber River bowfin on a percent frequency occurrence basis, with crayfish occurring, on average, in 3% (Fig. 6). However, fish remains had a higher frequency of occurrence in the diet of Lumber River bowfin than they did in the Black River bowfin diet, occurring on average in 47% of all stomachs containing food. There was a significantly lower occurrence ($P < 0.01$) of crustaceans in the diet in 1995 than in 1996. There was a significantly higher occurrence of fish remains in the diet in 1994 ($P < 0.01$), 1995 ($P < 0.01$), and 1997 ($P < 0.01$) than in 1996. All other frequency comparisons for each group were not significantly different. Among years, 1996 was the only year in which the occurrence of crustaceans in the diet was significantly higher ($P < 0.01$) than the occurrence of fish remains.

Crustaceans also dominated the diet numerically, accounting on average for 63% of all food items consumed (Fig. 7). Fish remains accounted, on average, for an

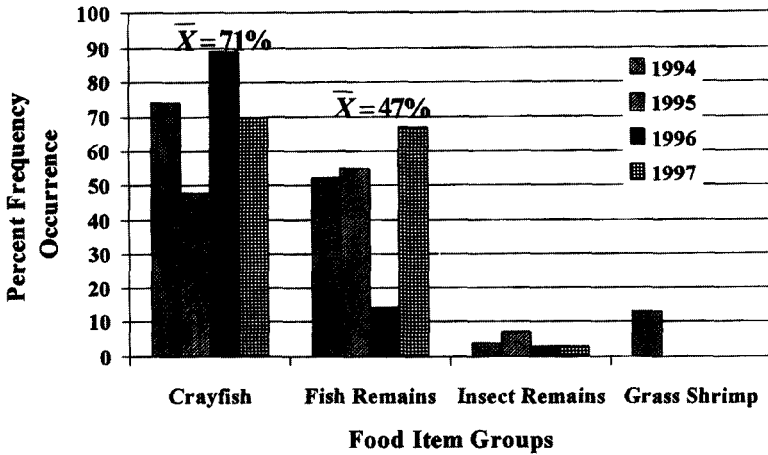


Figure 6. Percent frequency occurrence of major food item groups in bowfin stomachs collected from the Lumber River, 1994-1997.

additional 23% by number of all food items in the Lumber River bowfin diet. Numerically, even though the proportion of crustaceans in the diet was higher than the proportion of fish remains in all years, the difference in proportion was not statistically significant ($P>0.05$).

Fish remains dominated the Lumber River bowfin diet by weight, accounting on average for 73% of all food items consumed (Fig. 8). Crustaceans however, were the second most dominant food item by weight, comprising 27% of the stomach contents of Lumber River bowfin. By weight, there was a significantly higher proportion

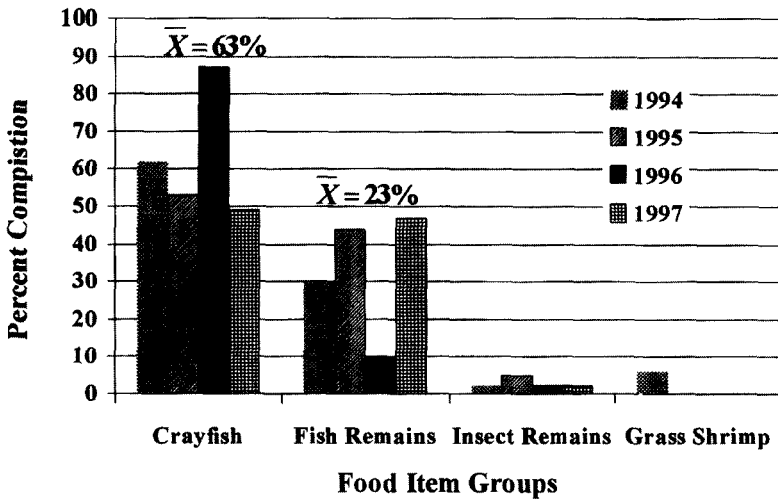


Figure 7. Percent composition (number) of major food item groups in bowfin stomachs collected from the Lumber River, 1994-1997.

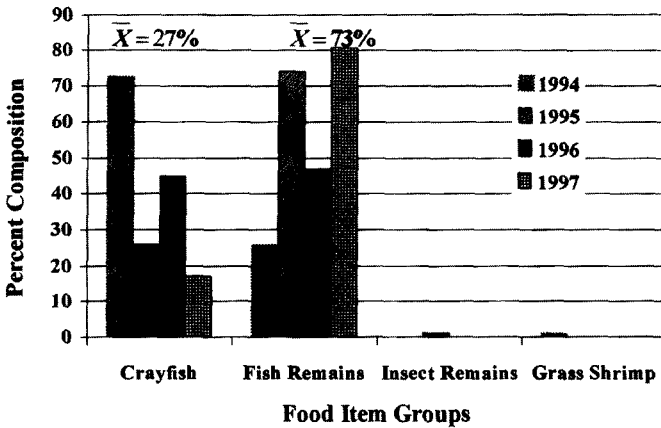


Figure 8. Percent composition (weight) of major food item groups in bowfin stomachs collected from the Lumber River, 1994–1997.

($P < 0.01$) of crustaceans in the Lumber River bowfin diet in 1994 than in any other study year. There were no significant differences in the proportions of crustaceans in the diet between 1995 and 1996 ($P > 0.05$) and 1997 ($P > 0.05$). There was no significant differences in the proportions of fish remains in the diet between 1994 and 1996 and between 1995 and 1996. All other comparisons were significantly different ($P < 0.01$). Finally, except for 1996 when there was no significant difference, the proportion by weight of crustaceans in the Lumber River bowfin diet was significantly higher ($P < 0.01$) than the proportion for fish remains.

Sunfish [warmouth, spotted sunfish, and redbreast sunfish (only 1 fish)] accounted on average for 40% by number and 47% by weight of the fish remains food

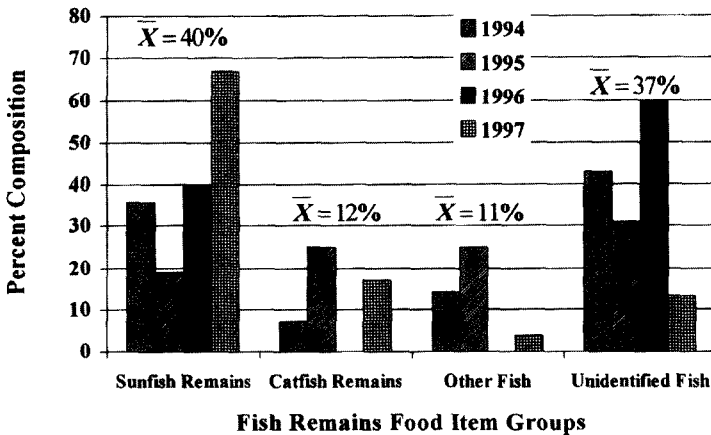


Figure 9. Percent composition (number) of fish remains food item groups in bowfin stomachs collected from the Lumber River.

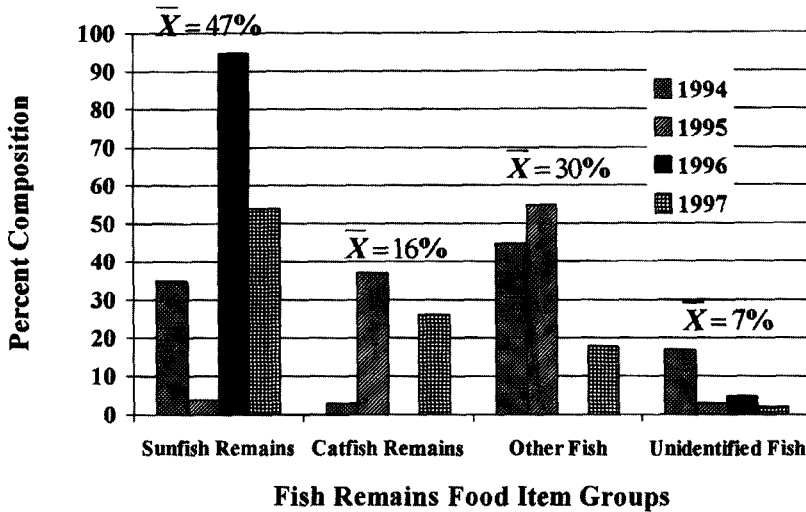


Figure 10. Percent composition (weight) of fish remains food item groups in bowfin stomachs collected from the Lumber River, 1994–1997.

item group in the Lumber River bowfin diet (Figs. 9, 10). Catfish (blue catfish) and bullheads (*Ameiurus* spp.) comprised an additional 12% by number and 16% by weight. Unidentified fish remains accounted for another 37% by number and 7% by weight of food items comprising this food item group. Other fish of minor importance in the diet were American eel and creek chubsucker (*Erimyzon oblongus*).

Discussion

Bowfin are considered by many fisheries biologists to be voracious predators and often are assumed to be detrimental to game fish populations. They have been known to feed exclusively on juvenile largemouth bass (*Micropterus salmoides*) in some areas (Schrenkeisen 1938). Lagler and Applegate (1942) reported sunfish occurred in 47% of 73 bowfin stomachs collected in Michigan. Berry (1955) reported crappie (*Pomoxis* spp.) were consumed by bowfin in Lake Newman, Florida, and recommended their removal.

Our data indicate crustaceans are the dominate food item consumed by Black River bowfin and are a major component in the diet of Lumber River bowfin. The diet of bowfin in our study was similar to that reported by researchers in earlier studies. Stacy (1967) reported crustaceans, grass shrimp, and crabs (*Callinectes* sp.) were the dominant food items consumed by 248 adult bowfin (22 to 72 cm) collected from several locations in Louisiana. Crayfish occurred in 76% of stomachs containing food and accounted for 35% by total weight and volume of all food items. Toole (1971) also reported crustaceans, primarily crayfish, were the dominant food item consumed by 434 bowfin in eastern Texas. In a 1968 study of 462 Suwannee River,

Georgia bowfin stomachs, Wyatt et al. (1968) reported crayfish were the single most dominant food item in the bowfin diet.

Other studies (Morris et al., 1968, Pflieger 1975) have shown crustaceans (crayfish) can serve as a major food item in the diet of flathead catfish. Ashley and Buff (1987) reported the number of crayfish consumed by Cape Fear River catfish in 1986 was significantly higher than the number consumed in 1979. Frequency of occurrence of crayfish in the flathead diet remained the same, however, indicating more crayfish may have been available for consumption in 1986.

Wyatt et al. (1968) also reported non-game fish such as bowfin, yellow bullhead (*A. natalis*), lake chubsucker (*E. sucetta*), and dollar sunfish (*L. marginatus*) accounted for a much more significant portion of the bowfin diet (18% vs. 3%) than did game fish. Our data appear to indicate just the opposite, game fish (primarily sunfish) comprised a much higher proportion (both by numbers and weight) of the bowfin diet in both rivers than did non-game fish.

Fish remains had a lower frequency of occurrence in the diet of Black River bowfin than they did in the diet of Lumber River bowfin. Fish kills, water quality changes, and predation by other species such as flathead catfish, could account for this difference. The Black River experienced 1 major and 2 minor (1 event per year) fish kill events (non-hurricane related) between 1994 and 1996. Flooding associated with hurricanes Bertha and Fran in September 1996 caused hypoxia and extensive fish kills in the Black River system and may have affected the abundance of all fish species during the final year of the study. The Lumber River was not affected by the hurricanes to the same degree as was the Black River.

Another possible factor for the lower frequency of occurrence of fish remains in the Black River bowfin diet could be competition and/or predation by other species. Flathead catfish have expanded into the lower portion of both river systems. However, they have been collected in the Black River for several years but were only first captured in the lower Lumber River in the summer of 1998. Flathead catfish are a dominant predator in the Cape Fear River (Guier et al. 1980, Ashley and Buff 1987), of which the Black River is a major tributary, and previous studies have indicated fish are the major component of the flathead catfish diet (Hackney 1965, Edmundson 1974, Guier et al. 1980, Davis 1985, Ashley and Buff 1987). Flathead catfish are thought to be responsible for significant declines in redbreast sunfish abundance in several South Carolina rivers (C. Thomason, pers. commun.). However, while sunfish were the dominant fish family comprising the fish remains food item group for both rivers, only 1 redbreast sunfish was identified in the stomach contents examined.

In summary, the diet of bowfin in the Black and Lumber rivers between 1994 and 1997 remained fairly constant and was dominated primarily by crayfish. Fish remains had a higher frequency of occurrence in the diet of Lumber River bowfin than they did in the diet of Black River bowfin. This difference was most likely the result of fish kills, water quality changes and predation by other species such as flathead catfish. Game fish (primarily sunfish) accounted for a much more significant portion of the bowfin diet than did non-game fish.

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