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ABSTRACT Channel catfish (*Ictalurus punctatus*) are native to Lake Sharpe, a Missouri River mainstem reservoir, and are common in angler catches. Channel catfish growth has declined since the formation of the reservoir in 1963. Mean lengths at time of capture for channel catfish ages 9, 10, 11, and 12 have decreased by 69, 55, 115, and 218 mm, respectively, since impoundment. The objective of this study was to document monthly food habits of channel catfish throughout the growing season (May-August) in Lake Sharpe to assess potential effects of diet on growth. Although channel catfish consumed both macroinvertebrates and fishes as expected, they also consumed large quantities of submergent aquatic vegetation. Consumed vegetation contributed 38–73% of the diet by weight over 2 channel catfish length groups (<280 mm and ≥280 mm total length) during the 4 months sampled. Consumption of substantial amounts of vegetation should be considered a suboptimal diet for channel catfish growth. Consequently, diets of channel catfish in Lake Sharpe could be a factor contributing to the observed slow growth of older catfish in this population.

KEY WORDS channel catfish, diets, growth, *Ictalurus punctatus*, Lake Sharpe

Channel catfish (*Ictalurus punctatus*) have a native distribution east of the Rocky Mountains, from southern Canada to northeastern Mexico, but exclude much of the Atlantic coastal plain (Hubert 1999*a*). In South Dakota, channel catfish are native to the Missouri River drainage (Hoagstrom et al. 2007). Although "catfish" was only the eighth most preferred group of fishes by South Dakota anglers (Gigliotti 2000), channel catfish were the fourth most caught fish species in Lake Sharpe, a South Dakota Missouri River reservoir, during 2007 (Potter et al. 2008).

Annual fish population surveys conducted by the South Dakota Department of Game, Fish and Parks (SDGFP) personnel suggest that channel catfish growth rates in Lake Sharpe have declined since the closure of Big Bend Dam in 1963 (Elrod 1974, Potter et al. 2008). In 1964, one year after impoundment, mean lengths at time of capture of age 9, 10, 11, and 12 year old channel catfish were 504, 532, 601, and 722 mm, respectively (Elrod 1974). In 2006 (this study), mean lengths at time of capture decreased to 435, 477, 486, and 504 mm.

Food habits of channel catfish could potentially affect growth. Several studies have reported that channel catfish are primarily omnivorous, feeding on vertebrates and invertebrates (Bailey and Harrison 1948, Tyus and Nikirk 1990, Hill et al. 1995, Michaletz 2006). Vegetation in channel catfish diets has been documented in other studies (Ware 1967, Mathur 1971, Tyus and Nikirk 1990, and Michaletz 2006), but none have reported diets comprised primarily of vegetation. Given that the caloric content of vegetation is substantially lower than the caloric content of invertebrates and fish, channel catfish diets could be limiting growth (Jobling 1995). Our objective was to document monthly food habits of channel catfish from May to August in Lake Sharpe to assess the potential effects of diet on growth.

STUDY AREA

Lake Sharpe is a 128-km long reservoir in central South Dakota bounded by Oahe Dam on the upper end and Big Bend Dam on the lower. The reservoir had a maximum depth of 24 m, a mean depth of 8.5 m, and a surface area of approximately 25,000 ha (Potter et al. 2008). Substrates were largely characterized as sand, gravel, shale, and silt. The reservoir was operated primarily for water control and hydroelectric power production; annual water level fluctuations were less than 1.1 m.

METHODS

We collected channel catfish during the last 2 weeks of each month from May to August 2006 throughout the reservoir using a combination of short term (i.e., ≤4 h) and overnight experimental gill net sets, and nighttime electrofishing. Gill nets were 91.4-m long by 1.8-m deep, five individual panels were 15.2-m long with bar mesh sizes of 12.7, 19.1, 25.4, 31.8, and 50.8 mm. We used a Smith Root SR-18 electrofishing boat with a 5.0-GPP control unit (Smith Root, Inc. Vancouver, WA, USA) to conduct nighttime electrofishing. Fish collection complied with South Dakota State University's (SDSU) Institutional

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Animal Care and Use protocol (Approval Number 03-E007).

We recorded fork length (FL; mm), weight (g), and removed a pectoral spine from all channel catfish captured. We converted fork length to total length (TL) using TL =1.08xFL (Page and Burr 1991). We used proportional size distribution (PSD; percentage of stock-length fish that also exceed quality length) and proportional size distribution of preferred-length fish (PSD-P; percentage of stock-length fish that also exceed preferred length) to index population size structure (Anderson and Neumann 1996, Guy et al. 2007). Minimum stock, quality, preferred, and memorable lengths for channel catfish are 280, 410, 610 and 710 mm TL, respectively (Gabelhouse 1984). We estimated ages of channel catfish from the basal recess of the pectoral spine using the methods outlined in Sneed (1951) and plotted age-frequency histograms. Ages tend to be underestimated when the basal process of the pectoral spine is used (Mayhew 1969). We only included channel catfish ages estimated by two readers in our analyses. We compared mean length at time of capture by cohort with the species-wide growth summary provided by Hubert (1999*b*).

We excised stomachs from all channel catfish collected and preserved them in 90% ethanol. We identified, counted, and weighed (wet weight; g) stomach contents in the laboratory. Food habits were first summarized as percent composition by weight (Bowen 1996) for individual fish and then means were determined each month for 2 length groups: <280 and ≥280 mm TL. While the larger length group encompasses a substantial range in fish lengths, sample sizes during some months precluded use of additional length categories.

RESULTS

We collected 451 channel catfish during 2006 (May = 74, June = 99, July = 121, August = 157). Total lengths of channel catfish ranged from 138 to 627 mm (Fig. 1). The PSD for the combined sample was 68 (95% confidence interval [CI] = 8), PSD-P was 4 (95% CI = 3) and no memorable-length (710 mm) fish were collected. Estimated ages of collected fish ranged from 3 to 21 years (n = 275) and the majority (73%) were between ages 7 and 10 years. Channel catfish mean TL at time of capture by age group ranged from 270 mm at age 3 to 614 mm at age 17 (Fig. 2).

Channel catfish diets were diverse. Invertebrates were more prevalent in channel catfish diets for both length groups during May and June, while prey fishes were more prevalent during July and August (Table 1). Similarly, smaller channel catfish (<280 mm) consumed more invertebrates, while larger fish (>280 mm) consumed more fish (Table 1). Ephemeropterans were the most common identifiable invertebrates consumed. The second most consumed invertebrate group was Coleoptera. The most common identifiable prey fish was gizzard shad (*Dorosoma cepedianum*), with age-0 fish (age was based on their small size; i.e., < 120 mm TL; Wuellner et al. 2008) being consumed only during July and August. Yellow perch (*Perca flavescens*) and walleye (*Sander vitreus*) were the only other identifiable prey fishes and they were infrequently consumed.

We also noted a high incidence of aquatic vegetation in channel catfish stomachs (Table 1). Percent composition by weight ranged from 38 to 73% across length groups and months. Many catfish had distended stomachs caused by the amount of aquatic vegetation present in their stomachs. We combined aquatic vegetation into a single category for diet analysis; however, curly-leaf pondweed (*Potamogeton crispus*) was the most consumed vegetation type in May and June, while July and August samples were dominated by some combination of coontail (*Ceratophyllum demersum*), Eurasian water milfoil (*Myriophyllum spicatum*), and white water-crowfoot (*Ranunculus aquatilis*). Filamentous algae (*Spirogyra* spp.) were observed in stomachs during all months.

DISCUSSION

Our Lake Sharpe channel catfish population sample exhibited a rather truncated size structure with no fish exceeding 650 mm TL despite the presence of substantial numbers of older fish. However, lack of large experimental gill net mesh sizes also may have caused the size structure to be underestimated. Few catfish (n=8) <200 mm indicated that smaller fish also were not effectively sampled. Buckmeier and Schlechte (2009) reported low catch rates of catfish <150 mm with experimental gill nets.

Channel catfish longevity is relatively high in Lake Sharpe; a literature review by Hubert (1999*b*) indicated that only 23 of 102 North American channel catfish populations contained fish older than age 11. The age structure of the Lake Sharpe channel catfish population is similar to that found in the Powder River, Wyoming, where channel catfish ages 21–23 were sampled (Gerhardt and Hubert 1991), but different than that found in other Missouri River reservoirs in South Dakota. Channel catfish sampled in Lake Francis Case and Lewis and Clark Lake had maximum ages of 14 (Sorenson and Knecht 2005) and 11 (Wickstrom 2006). Mean length for Lake Sharpe channel catfish at ages 3–5 ranked above the 50th percentile for the species growth summary provided by Hubert (1999*b*), indicating relatively fast growth. However, mean length at age for channel catfish at ages 6–10 was consistently below the 50th percentile reported by Hubert (1999*b*), indicating relatively slow growth. Both the truncated size structure and the slower growth for old fish indicated a potential limitation in available prey for channel catfish in Lake Sharpe, especially for larger fish.

Table 1. Stomach contents (mean percent by weight) by length group for channel catfish collected monthly (May – August) from Lake Sharpe, South Dakota, 2006.

	<208 mm				≥280 mm			
Prey taxon	May	June	July	August	May	June	July	August
Macroinvertibrates	42.8	9.7	19.6	12.8	27.9	7.8	17.8	7.1
Coleoptra	6.4	0.3	2.4	0.5	1.3	0.2	2.3	0.7
Decapoda	0.0	1.6	2.5	0.0	8.6	0.0	3.2	1.0
Ephemeroptera	15.6	0.6	3.5	6.8	15.3	6.1	11.6	0.6
Other invertebrates[a]	6.7	0.8	5.8	0.6	2.1	0.1	0.1	1.3
Unidentified invertebrates	14.1	6.4	5.4	4.9	0.6	1.4	0.6	3.5
Detritus	1.8	32.3	11.0	27.4	4.7	10.3	9.0	8.0
Vegetation	55.4	49.1	48.1	45.6	52.3	72.8	55.0	37.7
Fish	0.0	1.7	4.8	6.5	1.7	1.8	13.2	24.4
Gizzard shad	0.0	0.0	2.4	5.6	0.0	0.0	1.3	4.9
Percidae	0.0	0.0	2.4	0.0	0.0	0.0	0.0	1.9
Unidentified fish	0.0	1.7	0.0	0.9	1.7	1.8	11.9	17.6
Unidentified items	0.0	7.2	16.5	7.7	13.4	7.3	5.0	22.8

[a]Includes macroinvertebrates infrequently occurring (≤ 6.1% by weight) in channel catfish diets from orders diptera, gastropoda, hemiptera, heteroptera, hymenoptera, lepidoptera, odonata, and trichoptera.

Our diet analysis provided both expected and unexpected results. As expected, invertebrates were common in channel catfish diets early in the growing season, and more common in diets of the small length group compared with the large length group. Most food habits studies indicate that channel catfish are primarily omnivorous (Bailey and Harrison 1948, Kubeny 1992). Prey fishes were more prevalent late in the growing season and more common in diets for the larger length group. Age-0 gizzard shad were only consumed during the July and August samples, as previously documented for other piscivores in South Dakota reservoirs that had a shad prey base (Wuellner et al., *In Press*). Channel catfish diets tend to change with increasing fish size (Menzel 1943, Hill et al. 1995) and season (Bailey and Harrison 1948) as different prey items are available during different times of the season. Length at which channel catfish become more piscivorous seems to vary by geographic location (Bailey and Harrison 1948).

High incidence of aquatic vegetation in channel catfish stomachs was unexpected. To attain these high percentages by weight, amount of plant material per stomach was high relative to other food items. Distended stomachs of most channel catfish, caused by the amount of aquatic plants consumed, suggested that catfish purposefully consumed vegetation rather than being part of incidental consumption. Many studies have indicated that channel catfish are omnivorous with the majority of their diets typically being comprised of invertebrates and vertebrates (e.g., Bailey and Harrison 1948, Hesse et al. 1982, Hill et al. 1995). Few other studies have reported large amounts of vegetation being consumed (e.g., Ware 1967, Mathur 1971, Michaletz 2006). In Lake Oahe (the next Missouri River reservoir upstream from Lake Sharpe), Hill et al. (1995) found no aquatic vegetation in a seasonal evaluation of channel catfish stomach contents.

Channel catfish food habits may not be the only factor affecting growth. Studies have indicated that growth of channel catfish could be affected by water temperature (Andrews and Stickney 1972), water depth (Durham et al. 2005), water velocity, cover (Putman et al. 1995), geographical location (Durham et al. 2005), inter and intra-specific competition, and biological productivity (Hall and Jenkins 1952). Hayes et al. (1999) suggested that fish growth is likely influenced by a combination of various biotic and abiotic factors. Given the colder, hypolimnetic discharge from Lake Oahe into Lake Sharpe, the temperature regime in Sharpe also may contribute to channel catfish growth rates.

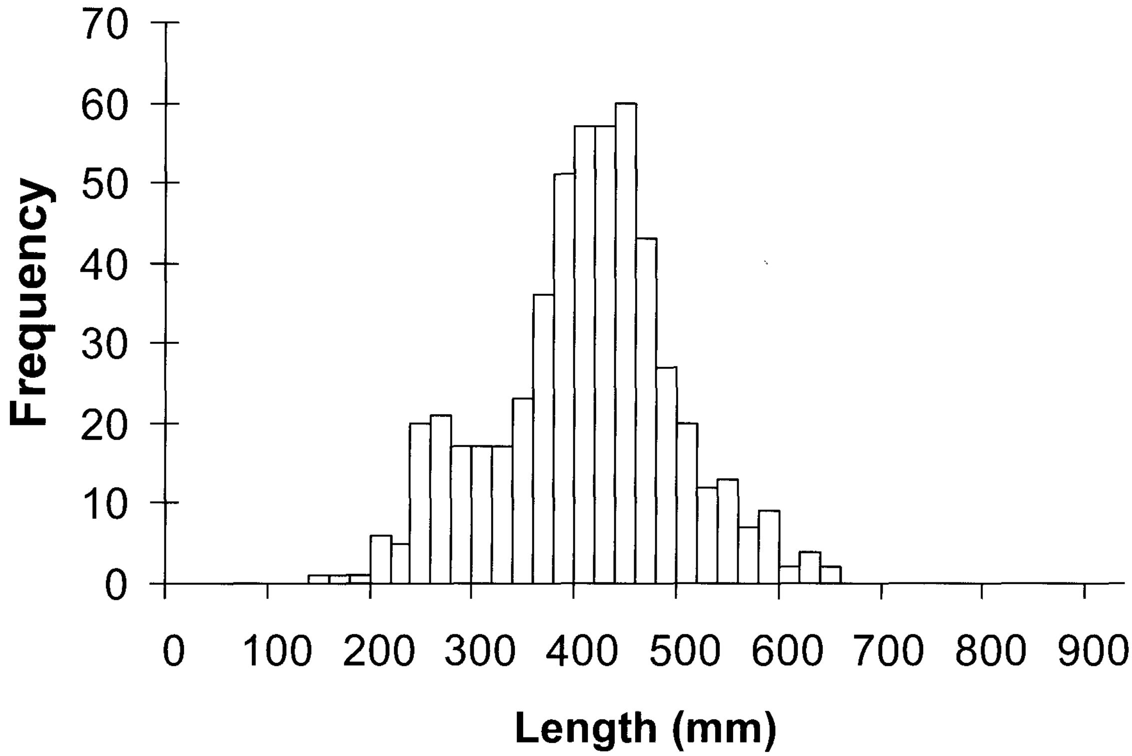

Figure 1. Total length frequency by 10-mm length groups for channel catfish sampled (n=451) in Lake Sharpe, South Dakota, 2006.

MANAGEMENT IMPLICATIONS

The high proportion of vegetation in channel catfish diets could indicate that channel catfish diet composition may be limiting their growth, especially for older (e.g., ≥ age 6) fish. Replacement of vegetation with a similar weight of higher energy food sources may lead to increased channel catfish growth rates and likely to concomitant increases in population size structure. Management strategies to increase prey availability in Lake Sharpe could provide higher energy food sources which could result in higher growth rates. Future studies should focus on other variables (i.e. water temperature, flow, turbidity, dissolved oxygen, and prey availability) that could potentially influence channel catfish feeding behavior and growth.

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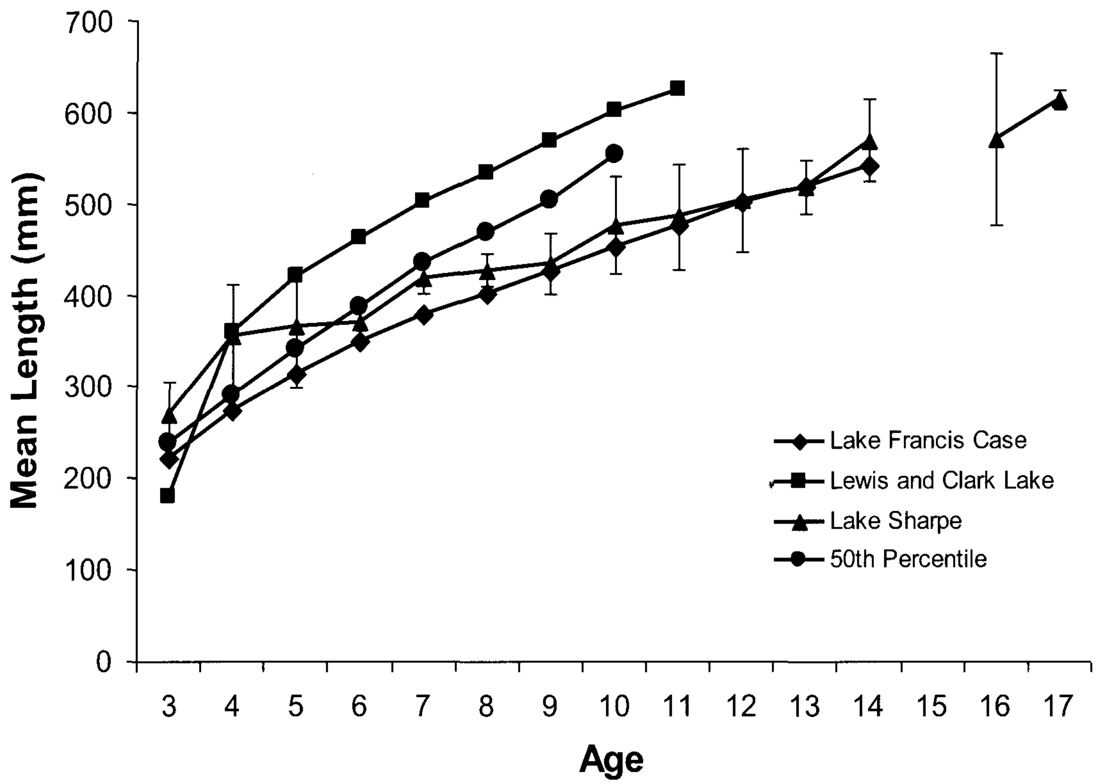

Figure 2. Mean total length (mm) at time of capture (Lake Sharpe and 50th percentile; Hubert 1999*b*) and mean back-calculated length at age (Lake Francis Case; Sorenson and Knecht 2005, and Lewis and Clark Lake; Wickstrom 2006) by age group for channel catfish across populations. Error bars represent the 95% confidence interval.

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