The Prairie Naturalist
Great Plains Natural Science Society

12-2010

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The Prairie Naturalist 42(3/4):130–137; 2010

# Population and Diet Assessment of White Bass in Lake Sharpe, South Dakota

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**ABSTRACT** White bass (*Morone chrysops*) have been introduced into all 4 South Dakota Missouri River reservoirs and compose a substantial proportion of the annual recreational harvest. To date, limited studies have examined white bass population dynamics and food habits in South Dakota Missouri River reservoirs. Our objective was to examine population dynamics and food habits of white bass in Lake Sharpe, a South Dakota mainstem Missouri River reservoir. White bass consistently consumed invertebrates during May but switched to a more piscivorous diet later in the growing season; most of the fish consumed were gizzard shad (*Dorosoma cepedianum*). Information from this study adds to the body of knowledge of white bass population dynamics and their role in fish communities that is necessary for successful management of those communities.

**KEY WORDS** food habits, *Morone chrysops*, population dynamics, white bass

White bass (*Morone chrysops*) are native to the Minnesota and Big Sioux drainages in South Dakota, the latter of which is nested within the Missouri River drainage (Bailey and Allum 1962). However, white bass are not native to the Missouri River mainstem in South Dakota and have been introduced into all four South Dakota Missouri River reservoirs (Bailey and Allum 1962, Ruelle 1971). White bass compose a seasonal but substantial portion of the recreational fish harvest in all four reservoirs (Willis et al. 1996, 2002).

To date, limited studies have examined white bass population dynamics and food habits in South Dakota Missouri River reservoirs (see Ruelle 1971, Willis et al. 1996, Beck et al. 1997, Beck 1998). Information on recruitment, growth, and mortality is necessary for effective management. Further, the potential exists for white bass to compete with other recreationally important species in these reservoirs such as walleye (*Sander vitreus*; Beck et al. 1998, Starostka 1999) and smallmouth bass (*Micropterus dolomieu*; see Wuellner et al. 2010*a*). Our objective was to examine population dynamics and food habits of white bass in Lake Sharpe, a mainstream Missouri River reservoir.

## STUDY AREA

Lake Sharpe is located in central South Dakota. This reservoir extends from Oahe Dam to Big Bend Dam with a surface area of ~25,000 ha (Stueven and Stewart 1996). Maximum and mean depths are 23.5 m and 9.5 m, respectively, and the bottom substrate is classified as sand, gravel, shale, and silt (Stueven and Stewart 1996). Lake Sharpe experiences relatively small annual water level fluctuations (<1.1 m) and is operated primarily for water control and hydropower purposes (Stueven and Stewart 1996). Fisheries management classification of this reservoir is cool and warm water permanent (Lott et al. 2006).

## METHODS

We sampled white bass throughout Lake Sharpe from May through August 2006 and 2007 using short-term (i.e., ≤4 hr) and overnight experimental monofilament gill net sets. We sampled fish during the last 2 weeks of every month. Though we did not standardize sampling locations, fish were sampled throughout the reservoir. Experimental gill nets were 91.4 m long and 1.89 m deep; bar mesh sizes of the six panels were 12.7, 19.1, 25.4, 31.8, and 50.8 mm. Fish collection was conducted under South Dakota State University Institutional Animal Care and Use Committee Approval Number 03-E007.

We measured total length [(TL); mm] and weighed (g) each white bass collected. We calculated proportional size distribution (PSD) values by year to index size structure; PSD is defined as the percentage of stock-length fish that exceed quality length; proportional size distribution of preferred-length (PSD-P) fish is the percentage of stock-length fish that also exceed preferred length, and proportional size distribution of memorable-length (PSD-M) fish is the percentage of stock-length fish that also exceed memorable length (Anderson and Neumann 1996, Guy et al. 2007). Minimum stock, quality, preferred, and memorable lengths for white bass are 150, 230, 300, and 380 mm TL, respectively (Gabelhouse 1984). We indexed fish condition using mean relative weight values ($W_r$; Murphy et al. 1990). We calculated mean $W_r$ by length group (e.g., stock-quality, quality-preferred, preferred-memorable) and month to avoid

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length-related bias and to reflect changes in prey availability throughout the growing season. We used analysis of variance (ANOVA) to determine differences in mean $W_r$ between length groups, months and years. Statistical significance was determined at $\alpha = 0.05$.

We removed sagittal otoliths from each white bass collected to determine ages of individuals. At least 1 otolith from each fish was cracked, sanded, and viewed in section independently by two readers; initial readings were done blindly and any discrepancies in age were settled by a third reader. We plotted age-frequency histograms by year. We noted several missing year classes in our plots; thus, we used the recruitment variability index (RVI) to assess relative recruitment variation among years (Guy 1993, Guy and Willis 1995). We calculated the index as:

$$RVI = [S_N/(N_m + N_p)] - N_m/N_p$$

where $S_N$ is the sum of the cumulative relative frequency distribution based on the number of fish in each age group; $N_m$ is the number of missing year-classes in the sample (excluding those year-classes older than the oldest fish collected in the sample); and $N_p$ is the number of year-classes present in the sample. The RVI ranges from −1 to 1, with values close to 1 indicating relatively stable recruitment (Guy 1993, Guy and Willis 1995). We combined age data with length data to assess growth. We calculated and plotted mean TL per cohort by year and fit a von Bertalanffy (1938) growth model to data collected in each year.

We excised whole stomachs in the field from each white bass collected and individual stomachs were stored in a 90% ethanol solution. Our goal was to collect 60 fish with food in their stomachs at both the upper and lower ends of the reservoir; however, our goal was rarely reached due to difficulty in catching fish during some months. In the laboratory, we identified, enumerated, and weighed (wet weight; g) stomach contents. We indexed food habits as percent composition by weight (Bowen 1996) by individual fish. We calculated a mean diet composition for all white bass by month and year. We made no attempts to calculate food habits by length categories due to the inadequate numbers of fish collected for some length groups in some months. Additionally, we made no comparisons of food habits between white bass collected in upper and lower Lake Sharpe

## RESULTS

More than twice as many white bass were collected in 2006 ($n$ = 313) than in 2007 ($n$ = 126). In both years, the greatest number of white bass was collected in August ($n$ = 147 and 63, respectively) compared to the other three months (May = 47 and 15, June = 66 and 12, July 53 and 36, respectively). Proportional size distribution indices were higher in 2007 than 2006 (Table 1); all white bass collected in 2007 exceeded quality length. Condition values were higher for smaller length categories in both 2006 ($F_{2,310}$ = 62.47, $P$ < 0.001) and 2007 ($F_{2,123}$ = 13.58, $P$ < 0.001). Condition generally increased throughout the growing season in both years (2006: $F_{2,309}$ = 52.60, $P$ < 0.001; 2007: $F_{3,122}$ = 21.97, $P$ < 0.001) and was generally higher among all length categories in 2006 compared to 2007 ($F_{1,437}$ = 10.26, $P$ < 0.001; Fig. 1).

Table 1. Proportional size distribution (PSD), proportional size distribution of preferred-length (PSD-P), and proportional size distribution of memorable-length (PSD-M) white bass collected in Lake Sharpe, South Dakota, in 2006 and 2007. Numbers in parentheses represent the 95% confidence interval.

| Year | PSD | PSD-P | PSD-M |
|---|---|---|---|
| 2006 | 85 (±7) | 60 (±10) | 9 (±6) |
| 2007 | 100 (±5) | 86 (±7) | 20 (±8) |

The range in white bass ages was similar during both years of this study (Fig 2). Ages-1 and -5 fish were equally more prevalent than other year classes in 2006. As expected, age-2 white bass dominated catches in 2007, followed by age-6 fish (Fig. 2). In 2006, the 1996, 2000, and 2002 year classes were not represented in the sample (Fig. 2). In 2007, individuals from the 1998 and 1999 year classes were not sampled (Fig. 2). Recruitment variability index values indicated somewhat erratic recruitment each year (Fig. 2).

Growth rates for white bass were relatively similar between 2006 and 2007, particularly for older (≥ 5 years) fish (Fig. 3). Growth was relatively rapid between ages-1 and -5 but slowed thereafter (Fig. 3). Growth rates of younger fish appeared to be more rapid in 2006 compared to 2007. Mean TL of Lake Sharpe white bass was larger or similar than back-calculated TL reported in other South Dakota Missouri River reservoirs, eastern natural lakes, and throughout Minnesota through age-5 (Fig. 3; Willis et al. 1997). However, mean back-calculated TL of white bass was larger in eastern natural lakes at age-6 than mean TL of Lake Sharpe white bass in 2006 and 2007 (Fig. 3).

White bass food habits were more diverse later in the growing season compared to the early season (Fig. 4). In May of both years, invertebrates composed the entire diets of collected white bass. In 2006, all invertebrates consumed were ephemeropterans, but dipterans were consumed in addition to ephemeropterans in 2007. Odonates were the only insects consumed in July 2006. Diets were not analyzed in June 2006 as no white bass that were collected had food in their stomachs. Prey fish were prevalent in white bass diets during the latter months of the growing season (June – August) in both years. The most common identifiable prey fish was gizzard shad (*Dorosoma cepedianum*). Other prey fishes consumed included emerald shiner (*Notropis atherinoides*), johnny darter (*Etheostoma nigrum*), rainbow smelt (*Osmerus mordax*), and yellow perch (*Perca flavescens*). One white bass was consumed in 2006. Unidentifiable larval fish were consumed in June 2007; otherwise, all prey fishes appeared to be juveniles or adults.

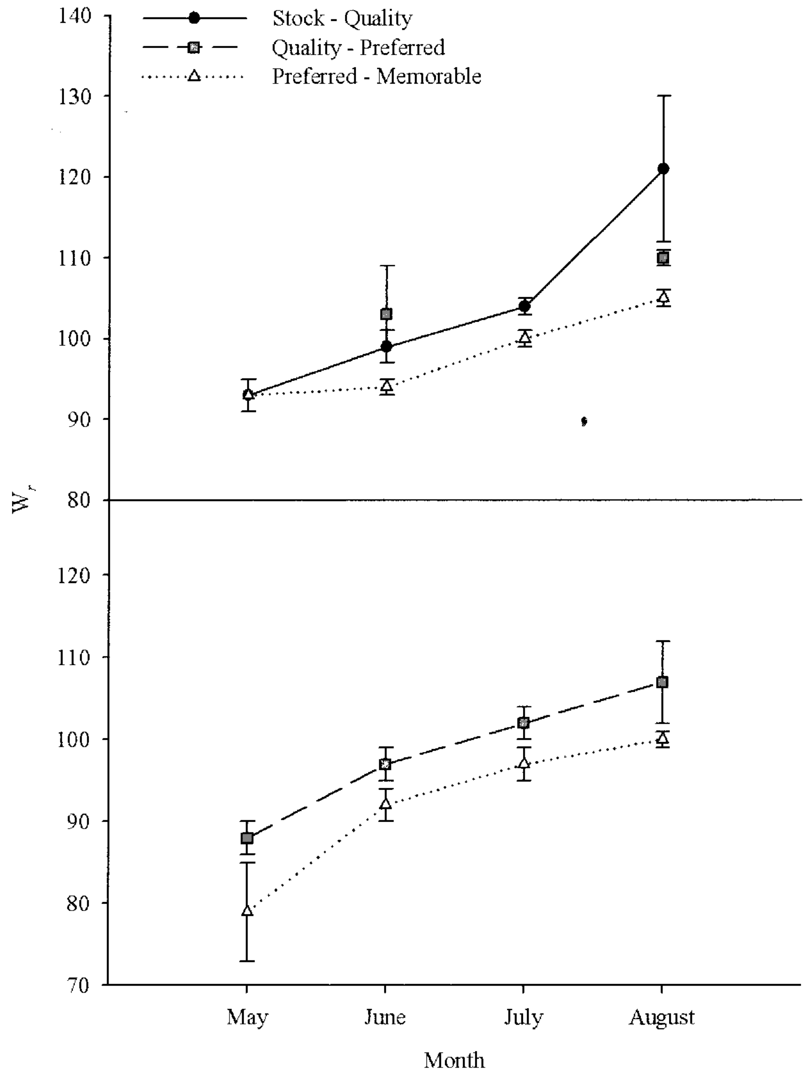


Figure 1. Mean relative weight ($W_r$) by month, length category, and year (2006: top panel; 2007: bottom panel) for white bass collected from Lake Sharpe, South Dakota. Error bars represent ± one standard error.

**DISCUSSION**

White bass are an important recreational species in South Dakota (Willis et al. 2002); information gleaned from this study adds to the body of knowledge of white bass population dynamics and their role in fish communities that is necessary for successful management of the communities. Size structure of Lake Sharpe white bass indicated a quality fishery. Proportional size distribution indices equaled or exceeded those of four Missouri reservoirs (Pomme De Terre Lake, Lake of the Ozarks, Table Rock Lake, and Bull Shoals Lake; Colvin 2002*a*) and 23 Nebraska reservoirs (Bauer 2002). Size structure may be related to year-class stability (Bauer 2002) or strength (Colvin 2002*a*). Bauer (2002) found a larger proportion of white bass >300 mm TL in Nebraska reservoirs that were characterized by less stable recruitment than those with more stable recruitment; the Lake Sharpe white bass population appears to have erratic recruitment. Proportional size distribution values were often <50 in years when age-0 catch rates were high and older age-groups were not abundant in four Missouri reservoirs (Colvin 2002*a*). High population size structure may also be related to growth or prey availability. Colvin (2002*a*) found that two reservoirs with faster white bass growth rates had consistently higher size structure than two reservoirs with slower growth rates. Bauer (2002) reported higher PSD but lower PSD-P values in Nebraska reservoirs with a gizzard shad prey base than those with a primarily alewife (*Alosa pseudoharengus*) prey base.

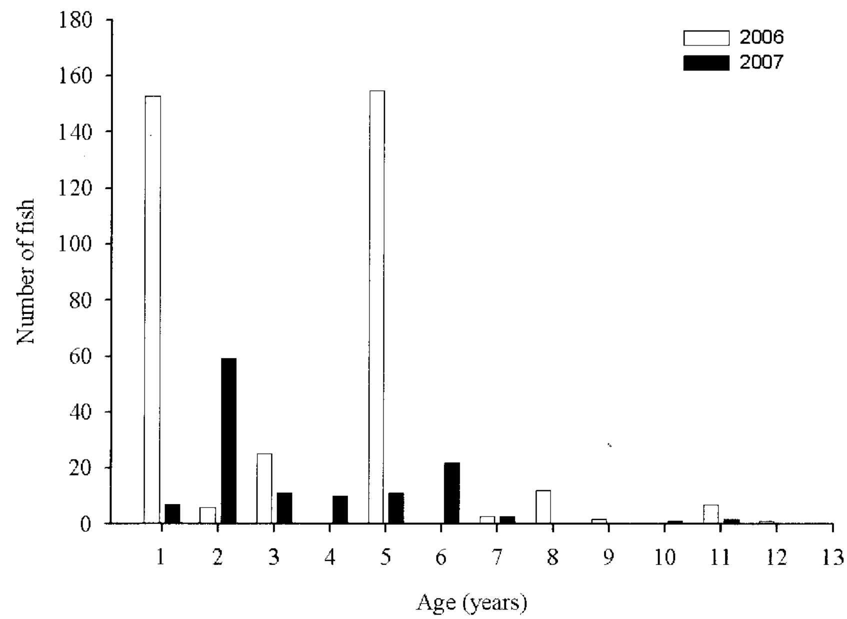


Figure 2. Age structure and recruitment variability index (RVI; 2006 = 0.56, 2007 = 0.54) for white bass collected from Lake Sharpe, South Dakota, 2006–2007.

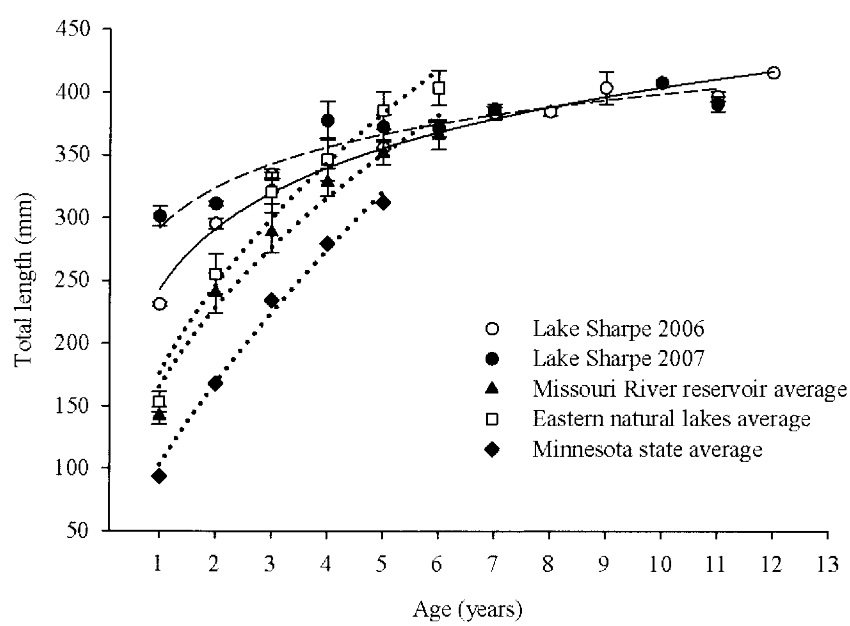


Figure 3. Mean total length (TL; mm) at time of capture by age group for white bass sampled in Lake Sharpe, South Dakota, 2006 (open circles) and 2007 (filled circles) and mean back-calculated total length averages for South Dakota Missouri River reservoirs excluding Lake Sharpe (filled triangles), eastern natural lakes (open squares), and Minnesota state averages (filled diamonds) adapted from Willis et al. (1997). Error bars represent ± one standard error. Equations (2006: $l_t = 388[1 - e^{-0.42(t + 1.18)}]$; 2007: $l_t = 413[1 - e^{-0.24(t + 3.81)}]$ represent the von Bertalanffy (1938) growth model fit to the data.

Growth of Lake Sharpe white bass often equaled or exceeded that of southern populations. In both years, many white bass reached quality length by age-1, and most were preferred length by age-2, similar to that observed in four Alabama reservoirs (Lovell and Maceina 2002) and 54 Texas reservoirs (Wilde and Muoneke 2001). Preferred sizes were attained within three years in Table Rock and Bull Shoals Lakes, Missouri (Colvin 2002*a*). Willis et al. (1997) found that growth of white bass ≤ age-6 in two eastern South Dakota natural lakes exceeded that of South Dakota Missouri River reservoirs. However, length-at-age data obtained in our study equaled or exceed those reported by Willis et al. (1997) for both eastern natural natural lakes and Missouri River reservoirs at most ages. These differences may be related to methodology; Willis et al. (1997) back-calculated length-at-age using scales, whereas otoliths were used to determine mean length-per-cohort in this study, which should provide more accurate and precise data. If Lake Sharpe white bass do grow faster than those in eastern natural lakes, growth may be related to differences in prey availability. White bass in eastern South Dakota natural lakes tended to be less piscivorous compared to other populations (Starostka 1999, Blackwell et al. 1999) and consumption of prey fish (particularly gizzard shad) has been linked to faster growth (Lovell and Maceina 2002, Colvin 2002*b*).

Lake Sharpe white bass tended to be older than those in more southern U.S. populations. Longevity of white bass may be related to latitude (Willis et al. 2002). White bass rarely exceeded age-4 in the Brazos River and Lake Whitney, Texas (Muoneke 1994) or age 3 in Nebraska reservoirs (Bauer 2002). Age-6 white bass were reported in Lake McConaughy, Nebraska (McCarraher et al. 1971), and age-7 bass were reported in Lake Winnebago, Wisconsin (Priegel 1971). Among eastern South Dakota natural lakes, maximum ages of white bass reported in Lakes Kampeska and Poinsett were 12 and 14, respectively (Soupir et al. 1997, Willis et al. 1998). Shorter growing seasons and lower overall mortality rates at northern latitudes may contribute to the longevity of those white bass populations relative to their southern counterparts (Willis et al. 2002).

Condition of Lake Sharpe white bass was generally high throughout the growing season among all size categories. Mean W*r* values of 93 to 107 were reported for Nebraska reservoirs for all size categories of white bass collected from late summer to late autumn (Bauer 2002). Relative weight values were >90 for all length groups in 4 Missouri reservoirs (Colvin 2002*a*). Condition of Lake Sharpe white bass generally increased throughout the growing season, likely reflecting changes in availability of different prey types. White bass consumed more invertebrates in the early part of the growing season but became more piscivorous after June, primarily consuming gizzard shad. Similar increases in condition during the growing season have been observed for Lake Sharpe walleyes and smallmouth bass as a result of changing prey availability (Wuellner et al. 2010*a*). Higher condition also may be related to fast growth rates. Lovell and Maceina (2002) found higher condition values of white bass in Alabama reservoirs with faster growth rates; it was thought that both condition and growth may be related to productivity and the availability of gizzard and threadfin shad (*Dorosoma petenense*) in these reservoirs.

Recruitment of white bass in Lake Sharpe appeared to be erratic (i.e., RVI<1), which is common among white bass populations within South Dakota (Soupir et al. 1997) and throughout their range (Colvin 1993). Climate, hydrology, and prey availability have been linked to white bass year-class strength in southern reservoirs (DiCenzo and Duval 2002, Schultz et al. 2002), but variation in bass recruitment exists on regional and local levels (Schultz et al. 2002). Abundance of age-0 white bass in Lake Sharpe was higher in years when January, April, and May air temperatures were cooler and July inflow and discharge were lower (Beck et al. 1997). However, other factors were related to age-0 white bass abundance in the other three South Dakota Missouri River reservoirs (Lakes Oahe and Francis Case and Lewis and Clark Lake; Beck et al. 1997). Pope et al. (1997) reported that white bass recruitment was synchronous between two South Dakota natural lakes. To date, no studies have examined the influence of prey availability on white bass recruitment in South Dakota waters. We did not attempt to relate prey availability to white bass year-class strength due to the erratic nature of the age structure of the Lake Sharpe white bass population. However, we suggest that monitoring of age-0 white bass abundance should be coupled with climate, reservoir operation, and prey availability data to better understand population dynamics of this species in reservoirs.

Food habits of Lake Sharpe white bass were similar to those reported in reservoirs with a gizzard shad prey base (Lovell and Maceina 2002, Colvin 2002*b*) and to walleye and smallmouth bass in the same system (Wuellner et al. 2010*a*). Invertebrates, particularly ephemeropterans, composed most of the diets of Lake Sharpe walleye during May and June in 2006 and 2007, but gizzard shad were consumed almost exclusively from July through October (Wuellner et al. 2010*a*). Smallmouth bass in Lake Sharpe consumed a wider variety of invertebrates in May and June but also fed largely on gizzard shad later in the growing season (Wuellner et al. 2010*a*). Based on this information, the potential for competition among white bass, walleye, and smallmouth bass exists. However, competition cannot exist without prey limitation (Crowder 1990). Evidence suggests that gizzard shad are abundant in Lake Sharpe (Wuellner et al. 2008, 2010*a*, 2010*b*) and thus competitive interactions are mitigated.

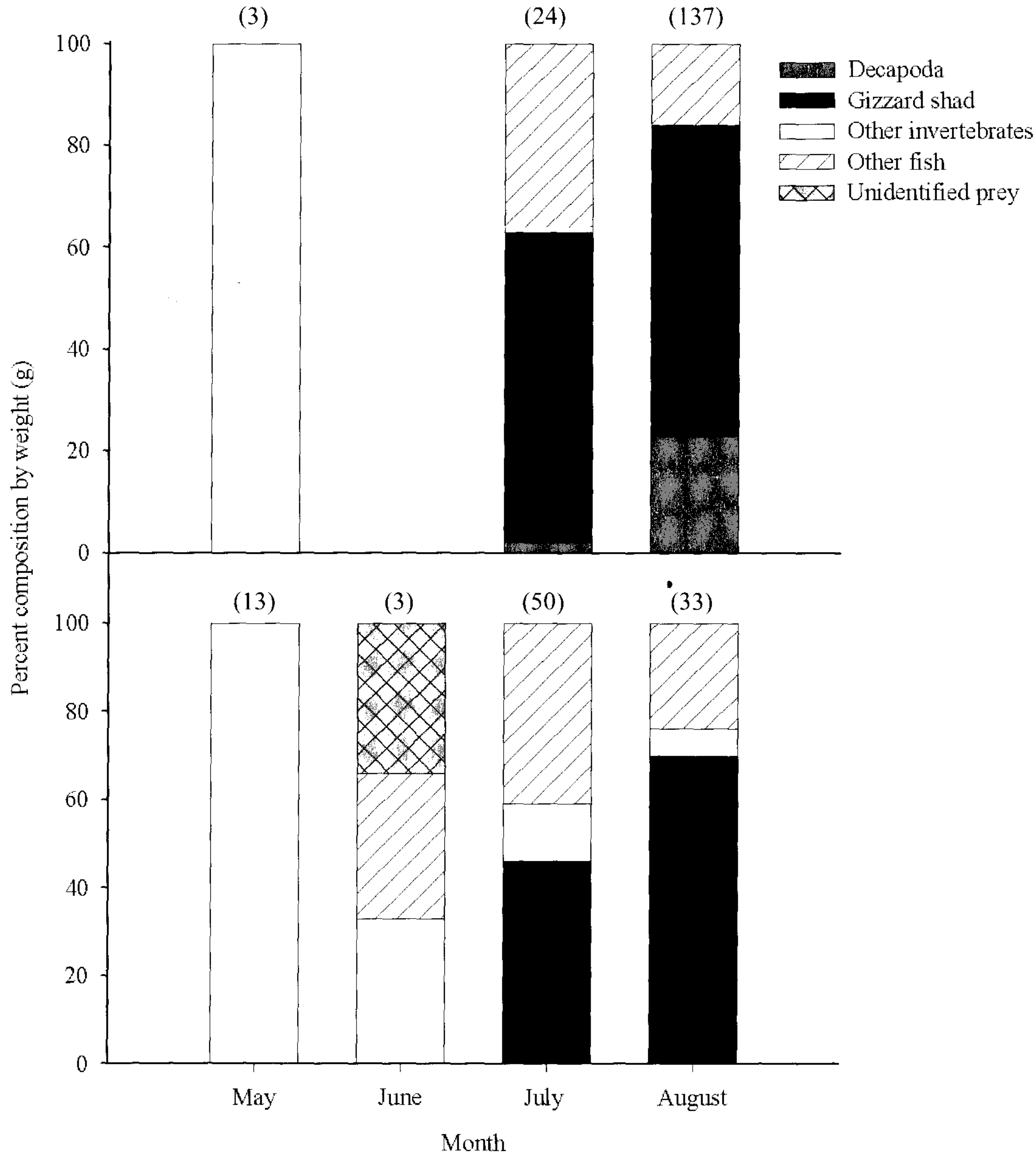


Figure 4. Monthly food habits summarized as percent composition by weight for white bass in Lake Sharpe, South Dakota, in 2006 (top panel) and 2007 (bottom panel). A food habits analysis was not completed in June 2006 as no fish were collected. Numbers in parentheses above the bars represent the number of stomachs analyzed each month.

## MANAGEMENT IMPLICATIONS

The white bass population in Lake Sharpe commonly produces a quality fishery with relatively high size structure and condition and fast growth despite erratic recruitment patterns. White bass likely do not compete with other Lake Sharpe predators at present due to abundance in prey and do serve as a prey source for walleye and smallmouth bass. Future research should focus on elucidating the relationships between climate, reservoir operation and prey availability on white bass recruitment dynamics in Lake Sharpe.

## ACKNOWLEDGMENTS

We thank J. Lott, K. Potter, and B. Hanten from the South Dakota Department of Game, Fish and Parks (SDGFP) for their assistance with field collection and J. Dagel, B. Galster, J. Grote, J. Meisenhoelder, B. Michaels, and J. Nordmann, for their help in the field and laboratory. Partial funding for this study was provided by Federal Aid in Sport Fish Restoration, Projects F-15-R, Study 1505, and F-21-R, Study 2102, administered through SDGFP, and by South Dakota State University.

## LITERATURE CITED

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–482 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland, USA.

Bailey, R. M., and M. O. Allum. 1962. Fishes of South Dakota. Miscellaneous Publication, Museum of Zoology, University of Michigan Publication 119, Ann Arbor, USA.

Bauer, D. L. 2002. White bass population differences in Nebraska reservoirs with gizzard shad or alewife prey bases. North American Journal of Fisheries Management 22:665–670.

Beck, H. D. 1998. Assessment of white bass populations in Missouri River impoundments located in South Dakota. Thesis, South Dakota State University, Brookings, USA.

Beck, H. D., D. W. Willis, D. G. Unkenholz, and C. C. Stone. 1997. Relations between environmental variables and age-0 white bass abundance in four Missouri River reservoirs. Journal of Freshwater Ecology 12:567–575.

Beck, H. D., A. B. Starostka, and D. W. Willis. 1998. Diet overlap of age-0 walleye and white bass in Lake Poinsett, South Dakota. Journal of Freshwater Ecology 13:425–431.

Blackwell, B. G., C. A. Soupir, and M. L. Brown. 1999. Seasonal diets of walleye and diet overlap with other top-level predators in two South Dakota lakes. South Dakota Department of Game, Fish and Parks, Fisheries Division Report 99-23, Pierre, USA.

Bowen, S. H. 1996. Quantitative description of the diet. Pages 513–532 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, second edition. American Fisheries Society, Bethesda, Maryland, USA.

Colvin, M. A. 1993. Ecology and management of white bass: a literature review. Missouri Department of Conservation, Federal Aid in Sport Fish Restoration, Project F-1-R-42, Study I-31, Job 1, Jefferson City, USA.

Colvin, M. A. 2002*a*. Population and fishery characteristics of white bass in four large Missouri reservoirs. North American Journal of Fisheries Management 22:677–689.

Colvin, M. A. 2002*b*. A comparison of gill netting and electrofishing as sampling techniques for white bass in Missouri's large reservoirs. North American Journal of Fisheries Management 22:690–702.

Crowder, L. B. 1990. Community ecology. Pages 609–632 *in* C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland, USA.

DiCenzo, V. J., and M. C. Duval. 2002. Importance of reservoir inflow in determining white bass year-class strength in three Virginia reservoirs. North American Journal of Fisheries Management 22:620–626.

Gabelhouse, D. W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273–285.

Guy, C. S. 1993. Structure, dynamics, and movement patterns for crappies in South Dakota waters. Dissertation, South Dakota State University, Brookings, USA.

Guy, C. S., and D. W. Willis. 1995. Population characteristics of black crappies in South Dakota waters: a case for ecosystem-specific management. North American Journal of Fisheries Management 15:754–765.

Guy, C. S., R. M. Neumann, D. W. Willis, and R. O. Anderson. 2007. Proportional size distribution (PSD): a further refinement of population size structure index terminology. Fisheries 32:348.

Lott, J. P., J. Erickson, A. Liengang, and K. Potter. 2006. Annual fish population and angler use, harvest, and preference surveys on Lake Sharpe, South Dakota, 2004. South Dakota Department of Game, Fish and Parks, Fisheries Division Report 06-03, Pierre, USA.

Lovell, R. G., and M. J. Maceina. 2002. Population assessment and minimum length limit evaluations for white bass in four Alabama reservoirs. North American Journal of Fisheries Management 22:609–619.

McCarraher, D. B., M. L. Madsen, and R. E. Thomas. 1971. Ecology and fishery management of McConaughy Reservoir, Nebraska. Pages 299–311 *in* G. E. Hall, editor. Reservoir fisheries and limnology. American Fisheries Society, Special Publication 8, Bethesda, Maryland, USA.

Muoneke, M. I. 1994. Dynamics of a heavily exploited Texas white bass population. North American Journal of Fisheries Management 14:415–422.

Murphy, B. R., M. L. Brown, and T. A. Springer. 1990. Evaluation of the relative weight ($W_r$) index, with new applications to walleye. North American Journal of Fisheries Management 10:85–97.

Pope, K. L., D. W. Willis, and D. O. Lucchesi. 1997. Influence of temperature and precipitation on age-0 white bass abundance in two South Dakota natural lakes. Journal of Freshwater Ecology 12:599–605.

Priegel, G. R. 1971. Age and rate of growth of the white bass in Lake Winnebago, Wisconsin. Transactions of the American Fisheries Society 100:567–569.

Ruelle, R. 1971. Factors influencing growth of white bass in Lewis and Clark Lake. Pages 411–423 *in* G. E.

Hall, editor. Reservoir fisheries and limnology. American Fisheries Society, Special Publication 8, Bethesda, Maryland, USA.

Schultz, R. D., C. S. Guy, and D. A. Robinson, Jr. 2002. Comparative influences of gizzard shad catch rates and reservoir hydrology on recruitment of white bass in Kansas reservoirs. North American Journal of Fisheries Management 22:671–676.

Slipke, J. W. and W. G. Duffy. 1997. Food habits of walleye in Shadehill Reservoir, South Dakota. Journal of Freshwater Ecology 12:11–17.

Soupir, C. A., B. G. Blackwell, and M. L. Brown. 1997. Relative precision among calcified structures for white bass age and growth assessment. Journal of Freshwater Ecology 12:11–17.

Starostka, A. B. 1999. Foot habits and diet overlap of age-1 and older walleye and white bass in Lake Poinsett, South Dakota. Thesis, South Dakota State University, Brookings, USA.

Stueven, E., and W. C. Stewart. 1996. 1995 South Dakota lakes assessment final report. South Dakota Department of Environment and Natural Resources, Pierre, USA.

von Bertalanffy, L. 1938. A quantitative theory of organic growth. Human Biology 10: 181–213.

Wilde, G. R., and M. I. Muoneke. 2001. Climate-related and morphoedaphic correlates of growth in white bass. Journal of Fish Biology 58:453–461.

Willis, D. W., H. D. Beck, B. A. Johnson, G. D. Simpson, and G. A. Wickstrom. 1996. Growth of white bass in South Dakota waters. South Dakota Department of Game, Fish and Parks, Fisheries Division Report 96-16, Pierre, USA.

Willis, D. W., H. D. Beck, C. A. Soupir, B. A. Johnson, G. D. Simpson, and G. A. Wickstrom. 1997. White bass growth in South Dakota waters. The Prairie Naturalist 29:111–118.

Willis, D. W., K. L. Pope, and D. O. Lucchesi. 1998. Factors related to recruitment of white bass and walleyes in eastern South Dakota natural lakes. South Dakota Department of Game, Fish and Parks, Fisheries Division Report 98-17, Pierre, USA.

Willis, D. W., C. P. Paukert, and B. G. Blackwell. 2002. Biology of white bass in eastern South Dakota glacial lakes. North American Journal of Fisheries Management 22:627–636.

Wuellner, M. R., B. D. S. Graeb, M. J. Ward, and D. W. Willis. 2008. Review of gizzard shad population dynamics at the northwestern edge of its range. Pages 637–653 *in* M. S. Allen, S. Sammons, and M. J. Maceina, editors. Balancing fisheries management and water uses for impounded river systems. American Fisheries Society, Symposium 62, Bethesda, Maryland, USA.

Wuellner, M. R., S. R. Chipps, D. W. Willis, and W. E. Adams, Jr. 2010*a*. Interactions between walleyes and smallmouth bass in a Missouri River reservoir with consideration of the influence of temperature and prey. North American Journal of Fisheries Management 30:445–463.

Wuellner, M. R., D. W. Willis, R. Hanten, K. Potter, and G. Galinat. 2010*b*. Predator-prey relations in large South Dakota reservoirs, job 2: gizzard shad dynamics in South Dakota reservoirs. South Dakota Department of Game, Fish and Parks, Fisheries Division Report 10-10, Pierre, USA.

*Submitted 9 August 2010. Accepted 30 November 2010. Associate Editor was Brian G. Blackwell.*