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SAUGER LIFE HISTORY IN THE LOWER PORTION OF THE UPPER MISSISSIPPI RIVER—Widespread declines have been observed in numerous riverine fish species due to a host of anthropogenic related perturbations such as channelization, dam creation, and exploitation (Graham 1997, Gerken and Paukert 2009). Understanding life history and population demographics of riverine fishes is critical to their conservation. Specific to our study, the Mississippi River has undergone extensive habitat modifications which have changed the Upper Mississippi River (UMR) from a typical lotic large, free flowing river to multiple reservoir-like pools with reduced flow (LePage 1980, Hurley et al. 1987). These habitat transformations may impact sauger (*Sander canadensis*) populations within the Mississippi River. Several studies have documented sauger population declines due to similar factors in other systems such as the Yellowstone River (McMahon and Gardner 2001), Tennessee River (Pegg et al. 1996), Missouri River (Hesse 1994, McMahon and Gardner 2001) and in tributaries of the Great Lakes (Rawson and Scholl 1978). Dams may limit upstream migration to preferred spawning habitat (Nelson 1968, Pegg et al. 1997) or facilitate high exploitation (Pegg et al. 1996, Maceina et al. 1998) of sauger. Because of recent population declines observed across their range, sauger are globally listed as a species of concern (NatureServe 2013). However, in systems where native sauger populations persist, they remain an important recreational species (Maceina et al. 1998, Betolli et al. 2000, Pitlo et al. 2004, Meerbeek 2008, Meerbeek and Hoxmeier 2011) and top-level predator. Knowledge of population dynamics provides a basis for effective management and conservation of populations, but little is known about sauger dynamics within the lower portion of the UMR. Therefore, our objective was to quantify sauger recruitment, growth, and mortality within Pool 22 of the Upper Mississippi River.

We collected sauger from Pool 22 of the UMR which extends from Lock and Dam 21 (Quincy, Illinois) downstream to Lock and Dam 22 (Saverton, Illinois; river kilometers 301–325). We set ten overnight experimental gill nets each day for five days in late March 2011. Gill nets were 61 m long and were composed of four 15.25-m panels of 38.1, 50.8, 76.2, and 101.6-mm bar mesh. We placed sauger on ice and returned them to the laboratory for further processing.

In the lab, we recorded total length (TL; mm), weight (g) and sex of all sauger. We removed gonads and sagittal otoliths from each sauger. To estimate age, we sectioned, burned, and submerged otoliths in water under a dissecting microscope (4–10 ×) following procedures described by Heidinger and Clodfelter (1987). We reported annuli independently using two experienced readers who had no knowledge of fish length. If age estimates differed between readers, both readers re-observed the structure until a consensus was reached; consensus was reached in all cases.

We collected 101 sauger in our sample. We observed a skewed sex ratio towards females (74% female; 26% male), thus, we eliminated all males from further analyses. To estimate year-class strength and total annual mortality among females, we created an age-frequency histogram from log-transformed catch-at-age data and calculated a weighted catch-curve regression analysis (Maceina and Pereira 2007) using Fisheries Analyses and Modeling Simulator (FAMS; Slipke and Maceina 2010) software. The sign and magnitude of residuals from the catch-curve regression indicated relative year-class strength, where larger, positive residuals indicated years of higher recruitment and zero or negative residuals indicated years of poorer recruitment. We calculated instantaneous mortality (Z) from the slope of the regression from the descending right limb of the age-frequency distribution. We estimated total annual mortality as $1 - e^{(-Z)}$ and assessed growth by fitting a von Bertalanffy (1938) model for all female fish using FAMS software (Slipke and Maceina 2010).

Five cohorts of female sauger were present in our sample (i.e., ages 3–7). The 2008 year class (i.e., age-3) appeared to be the most abundant (Fig. 1). The 2008 and 2006 year classes appeared to be the strongest with residuals resulting in 0.09 and 0.677, respectively. The 2007, 2005 and 2004 year classes were weaker with residuals of –0.51, –0.018 and –0.295, respectively. Two cohorts (i.e., ages 1 and 2) were not sampled during our study possibly because these year classes had not recruited to our gear at the time of sampling. Total annual mortality rate among females ages 3 through 7 was 47.3% ($r^2 = 0.82$, $n = 75$, $P = 0.03$). Mean-length-at-age of female sauger was comparable to mean-length-at-age of sauger of both sexes from the Tennessee River (Buckmeier 1995) and was higher than that of sauger of both sexes from Pool 13 of the Upper Mississippi River (Pitlo et al. 2004; Fig. 2). von Bertalanffy growth functions adequately described sauger mean length at age for all female fish ($L_{inf} = 514.30$, $K = 0.70$, $t_0 = 0.77$, $n = 75$, $P < 0.001$, $r^2 = 0.96$). The von Bertalanffy growth coefficient for our study was considerably higher than those for sauger within the Missouri River (Braaten and Guy 2002) and Pool 4 of the Upper Mississippi River (Mammoliti 2007).

Prior to our study, the status of sauger within Pool 22 was unknown; however, we provided baseline characteristics needed for future comparisons. The lack of male sauger in our sample prevented assessment of the entire sauger population in Pool 22 of the UMR. We are unaware if this is related to sampling bias, sex-specific habitat, or if this is the actual sex structure of the population. However, assessment of female sauger does provide some insight. The maximum age (i.e., 7 years) of female sauger within our sample was lower than that reported at a more northerly location on the Mississippi River (Pitlo et al. 2004). Scott and Crossman (1998) found that maximum age in the north appeared to be higher than in the south. Differences in longevity relative to northern and southern latitudes have been documented for *Sander* spp. populations along a latitudinal gradient in which fish in southern latitudes grew faster, matured earlier and died at a younger age than fish in northern latitudes (Beverton 1987). However, because of our small sample size, we may have failed to capture older fish, thus additional sampling is needed.

Total annual mortality for female sauger in our study was comparable to mortality rates observed by Steuck (2006) in Pools 11 and 13 of the UMR and by many of the states within the Mississippi Interstate Cooperative Resource Association (MICRA; Mammoliti 2007). However, Jaeger et al. (2005) documented lower mortality in the Yellowstone River than our study. Dames and Brown (2010) indicated that mortality rates of sauger in Pool 22 were due to natural causes rather than exploitation. It is unknown at this time what role habitat alteration and fragmentation plays in mortality of sauger in this particular reach.

This study provides reference data to inform management and conservation efforts, which is currently lacking within the lower portion of the UMR for sauger. However, because our sampling was limited, more information is needed to fully assess the population. We recommend sampling a wider range of habitats to attempt to capture a larger sample of male sauger. Future efforts also should focus on identifying potential factors that regulate recruitment such as use and availability of spawning sites, age-0 habitat, forage availability, and predation by and competition with native and non-native species. Monitoring growth and determining the source of mortality for sauger will provide the framework for future efforts and aid fisheries managers in conserving sauger in the UMR.

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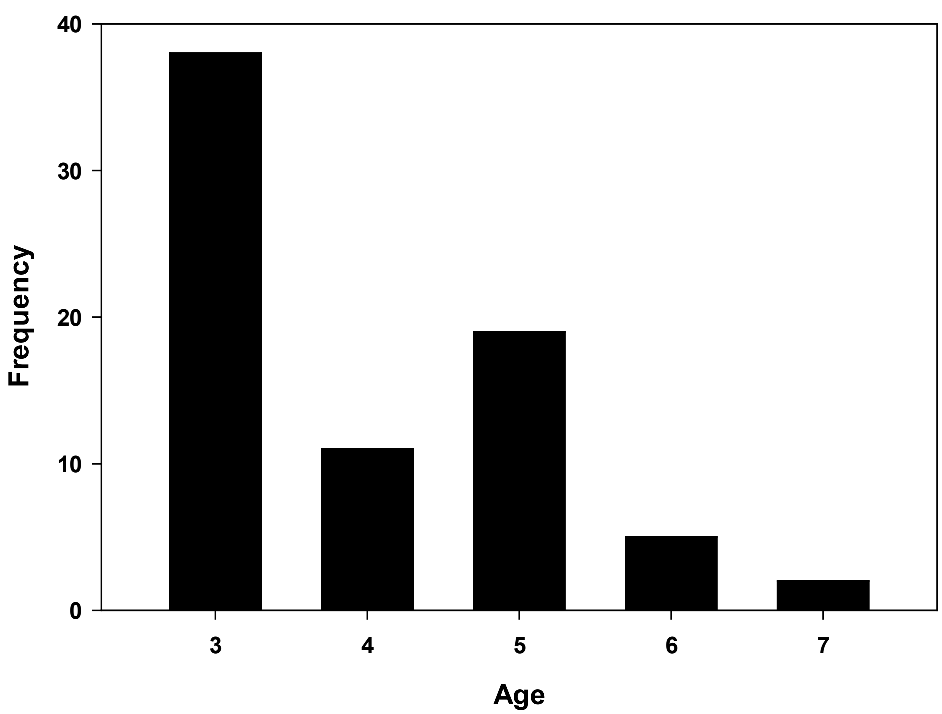

Figure 1. Age-frequency distribution of female sauger (r^2 = 0.82; P = 0.03, n = 75) sampled in Upper Mississippi River Pool 22, Missouri, USA in spring 2011.

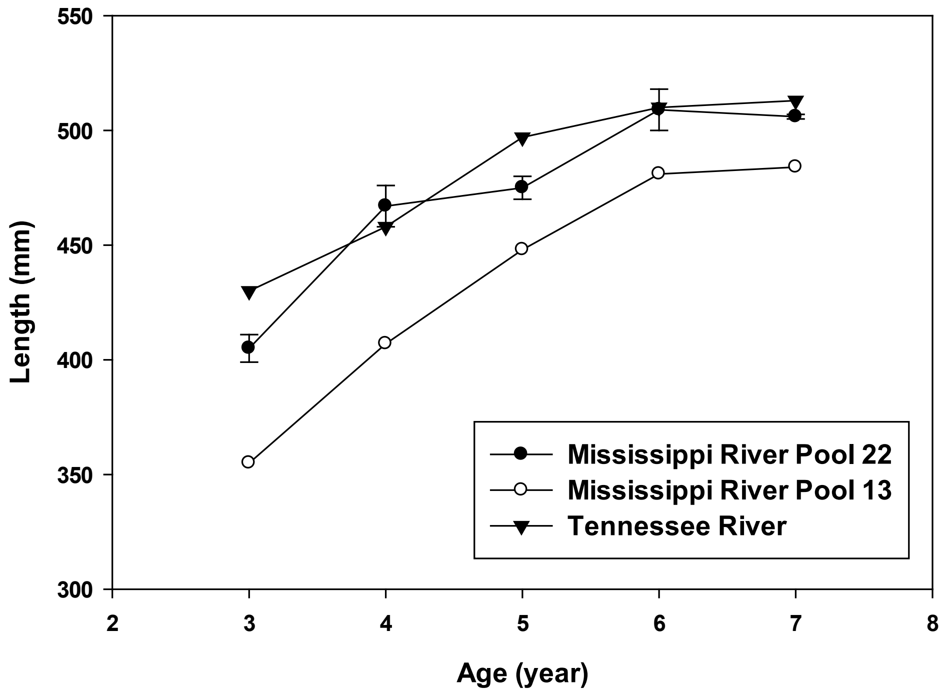

Figure 2. Mean-length-at-age (mm) with standard error bars of female sauger (n = 75) from Pool 13, Iowa, USA and Pool 22 Missouri, USA (RKM 301–325) of the Upper Mississippi River and Tennessee River, Tennessee, USA. Mean-length-at-age for Mississippi River Pool 13 was obtained from Pitlo et al. (2004) and for the Tennessee River from Buckmeier (1995).

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