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Age, Growth, and Mortality of Shovelnose Sturgeon in the Lower Mississippi River

JAMES V. MORROW, JR.,* JAMES P. KIRK, K. JACK KILLGORE, AND STEVEN G. GEORGE

U. S. Army Corps of Engineers, Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, Mississippi 39180, USA

Abstract.—Two hundred of 295 shovelnose sturgeon *Scaphirhynchus platorynchus* captured in the Mississippi River near Rosedale and Vicksburg, Mississippi, were aged by examining sectioned pectoral fin rays. Ages ranged from 2 to 16 years, and the annual mortality was 20% for ages 7 and greater. The weight (W, g), to fork length (FL, mm) relation was $W = 0.000001257\ \mathrm{FL}^{3.174}$ ($R^2 = 0.87$). The von Bertalanffy growth equation for fork length was $\mathrm{FL} = 730(1 - e^{-0.213(t+0.972)})$; the equation for weight was $W = 1{,}604(1 - e^{-0.148(t-1.841)})$. Mortality and mean length at age were less than has been reported for upper Mississippi River populations of shovelnose sturgeon. Knowledge of causes of mortality of shovelnose sturgeon may have applications in management of the sympatric pallid sturgeon *Scaphirhynchus albus.*

The shovelnose sturgeon *Scaphirhynchus platorynchus* is the only one of three species of North American river sturgeons (genus *Scaphirhynchus*) that is not currently listed or is a candidate for listing under the Federal Endangered Species Act. Shovelnose sturgeon historically inhabited most large rivers in the Mississippi and Rio Grande River systems but have been extirpated from the Rio Grande drainage and possibly the Tennessee River as well (Etnier and Starnes 1993). Shovelnose sturgeon are locally common and support commercial fisheries in portions of the Mississippi and Missouri rivers (Kline and Golden 1979; Carlson et al. 1985; Hurley et al. 1987).

Habitat alterations and overfishing have greatly reduced most North American sturgeon populations (Birstein 1993). However, shovelnose sturgeon appear to be more resilient than other sturgeon species, possibly due to size and life history. With a maximum fork length (FL) of less than 1,000 mm (Lee 1980; Berg 1981), shovelnose sturgeon are relatively small and may be less commercially valuable than other sturgeons (Carlander 1954). Shovelnose sturgeon also reach sexual maturity at an early age, approximately 5–7 years (Helms 1974; Farbee 1979), compared with 10–16 years for most other sturgeon species (Birstein 1993), which may enable them to better withstand fishing pressure. Despite these factors, catches of shovelnose sturgeon in the upper Mississippi River declined dramatically before construction of cross-channel dams (Carlander 1954), perhaps because they were overfished.

The shovelnose sturgeon is the only sturgeon species which still supports commercial fisheries in the central United States, and market price is high compared with other commercial fish species in the upper Mississippi River basin (Becker 1983). Commercial harvest of this species is banned in Louisiana, but game and fish regulations do not restrict harvest in other lower Mississippi River states (i.e., Arkansas, Kentucky, Missouri, Mississippi,[1] Tennessee). Furthermore, very little is known of the ecology or population dynamics of this species or others in the genus. In this study, we examine age structure, growth, and mortality rate of shovelnose sturgeon in the lower Mississippi River and use those data to evaluate the vulnerability of this population to overharvest. This study may also provide information useful for managing pallid sturgeon *Scaphirhynchus albus* in the lower Mississippi River.

Methods

Between 15 September 1995 and 26 February 1997, shovelnose sturgeon were sampled by a commercial fisher (under contract) from the Mississippi River near Rosedale, Mississippi (river kilometer 941 from the river's mouth). All sampling took place between late summer (earliest attempt on 15 September) and early spring (latest attempt on 9 April). The primary collection method was trotlines, 61 m long rigged with 50 number 2.0 hooks spaced at 1.2-m intervals, on 0.25 m dropper lines. Trotlines were baited with night crawlers, set parallel to the current at the edge of the main channel in depths of 7.5–10.5 m, and fished overnight. Fish captured before 1 January 1997 were

* Corresponding author: morrowj@ex1.wes.army.mil

[1] The state of Mississippi closed its shovelnose sturgeon fishery while this paper was in press.

frozen prior to processing. In the laboratory, FL was measured to the nearest millimeter, weight (W) was measured to the nearest 20 g, and the anterior ray of one pectoral fin was removed.

Beginning on 1 January 1997, we accompanied the commercial fisher to measure, weigh, remove fin rays, tag, and release any shovelnose sturgeon captured. In addition to the trotlines fished near Rosedale, one trammel net (92 m long, with 75-mm-bar mesh) was also fished near Rosedale on 22 January 1997, and trotlines were fished near Vicksburg, Mississippi (river kilometer 706), on 6 March 1997 (25 hooks) and on 12 March 1997 (50 hooks).

Pectoral fin rays were prepared as described by Rien and Beamesderfer (1994). Cross-sections, 0.46–0.58 mm thick, were cut with a Buehler low-speed saw, polished with 1,500- and 2,000-grit wet sandpaper, and mounted on a microscope slide with clear fingernail polish. Sections were examined with a binocular microscope at 100× magnification with transmitted light. Color photographs were made of 34 fin ray sections and were examined by two readers working together. Annuli consisted of a continuous light band following a dark band, and fish age in years was considered to be equal to number of annuli. Each reader then independently examined fin ray sections and estimated age. When estimated ages differed, fin ray sections were examined a third time by both readers to determine the final age estimate and reasons for disagreement.

A length–weight relation was estimated with a power function (Ricker 1975): $W = a(\mathrm{FL})^b$. Von Bertalanffy growth equations were calculated for fork length, $\mathrm{FL} = \mathrm{L}_\infty[1 - e^{-\mathrm{K}(t-t_0)}]$, and weight, $\mathrm{W} = \mathrm{W}_\infty[1 - e^{-\mathrm{K}(t-t_0)}]$ (von Bertalanffy 1938), where FL is fork length (mm), L_∞ is asymptotic length, W is the weight in grams, W_∞ is the asymptotic weight, t is age (years), t_0 is hypothetical age at length zero or weight zero, and K is Brody growth coefficient. Instantaneous rate of total mortality (Z) was estimated with a catch curve (Ricker 1975; Van Den Avyle 1993) that assumed constant recruitment, constant mortality among age classes, and equal vulnerability to gear for age-classes 7 years and greater.

Results

In all, 295 shovelnose sturgeon were captured between 15 October 1995 and 12 March 1997. Of these, 284 were captured in the Mississippi River near Rosedale (270 on trotlines and 14 in a trammel net), and 11 fish were captured in the Mississippi River near Vicksburg (all on trotlines). Catch per unit effort (CPUE) between 15 September 1995 and 1 January 1997 is unknown, but for 20 trotline sets between 1 January and 12 March 1997, CPUE was 0.116 shovelnose sturgeon per trotline hook-night (range = 0 - 0.340; SD = 0.101). Trotline CPUEs near Vicksburg (mean = 0.140; SD = 0.282; N = 2) and Rosedale (mean = 0.113; SD = 0.106) were not significantly different ($t = 0.34$; $P < t = 0.735$).

Mean fork length was 611 mm (range = 310–823 mm, SD = 76.6 mm, Figure 1), and mean weight was 933 g (range = 98–2,100 g, SD = 389 g). The W to FL relation was $W = 0.000000206\mathrm{FL}^{3.453}$ for frozen fish ($r^2 = 0.91$, $N = 157$), $W = 0.00001372\mathrm{FL}^{2.804}$ for live fish ($r^2 = 0.83$, $N = 115$), and $W = 0.000001257\mathrm{FL}^{3.174}$ overall ($r^2 = 0.87$, $N = 272$).

Two hundred shovelnose sturgeon were aged. Initial agreement in ages between two readers was 31.5% and was inversely correlated with estimated age of the fish. Of 137 occasions where initial age estimates disagreed, 52% were by 1 year, 31% by 2 years, 9% by 3 years, and 7% by 4 years or more. Disagreement in initial age estimates was caused by uncertainty in location of the first annulus, presence of double annuli, false annuli (discontinuous light bands), and bunching of annuli on the fin ray margin in older fish. Final age estimates, agreed upon by both readers, were greater than either initial age estimate 11 times, equal to the high initial estimate 93 times, between the initial estimates 19 times, and equal to the low initial estimate 14 times. On no occasion was the final age estimate less than the lowest initial estimate. Final age estimates ranged from 2 to 16 years with a mean of 8.1 years (Figure 2).

Mean fork lengths at capture ranged from 338 mm at age 2 to 707 mm at age 16 (Figure 3). The von Bertalanffy growth equation for length was $\mathrm{FL} = 730(1 - e^{-0.213(t+0.972)})$; $R^2 = 0.99$. The equation for weight was $W = 1{,}604(1 - e^{-0.148(t-1.841)})$; $R^2 = 0.93$. Shovelnose sturgeon became fully vulnerable to our trotlines at age 7 or a length of 625 mm FL (Figures 1, 2). Instantaneous rate of total mortality, Z, for ages 7 and greater was 0.220 ($r^2 = 0.82$), which converts to an annual mortality of 20%.

Discussion

Shovelnose sturgeon appeared to be abundant at the two lower Mississippi River locations we sampled. Numbers have apparently declined in the up-

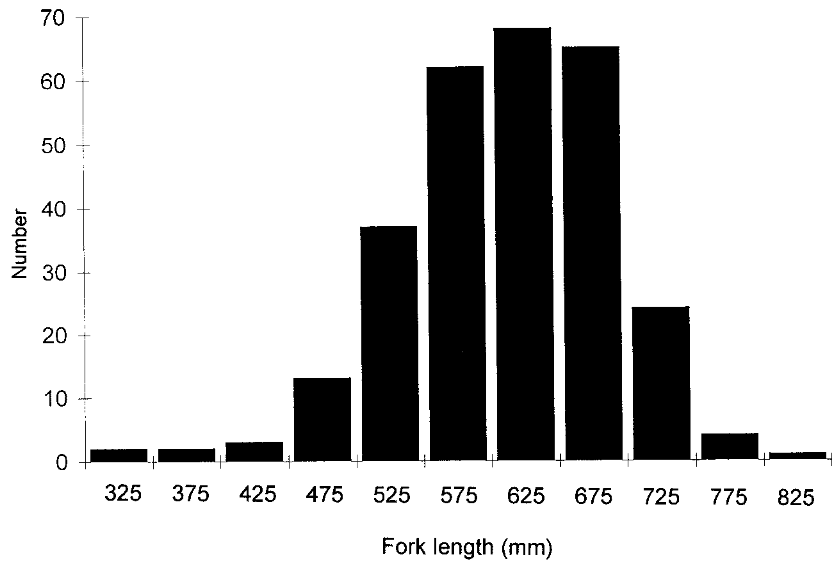

FIGURE 1.—Length frequency of 281 lower Mississippi River shovelnose sturgeon captured between 15 October 1995 and 12 March 1997.

per Mississippi River, possibly due to the impacts of cross-channel dams (Helms 1974; Hurley et al. 1987) or overfishing. Unfortunately, we have no historical data sets of sturgeon populations for the lower Mississippi River, so trends cannot be assessed. However, the lower Mississippi River is free of cross-channel dams, and thus shovelnose sturgeon populations may have fared well.

Aging sturgeon by examining sections of fin rays is an established technique (Zweiacker 1963; Dadswell 1979; Taubert 1980; Keenlyne and Jenkins 1993; Rossiter et al. 1995) and has been validated for lake sturgeon *Acipenser fulvescens* (Rossiter et al. 1995) and upper Mississippi River shovelnose sturgeon (Helms 1974). Shovelnose sturgeon younger than age 6 were relatively easy

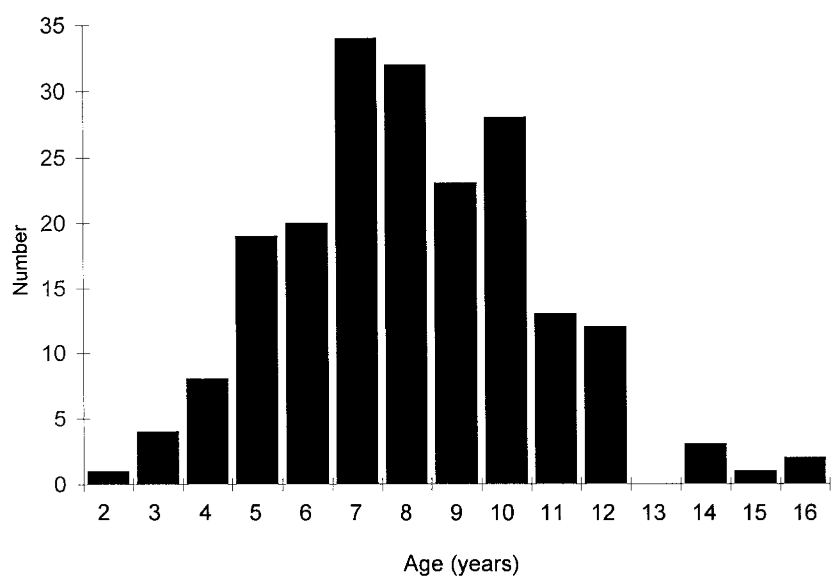

FIGURE 2.—Age frequency of 200 lower Mississippi River shovelnose sturgeon captured between 15 October 1995 and 12 March 1997.

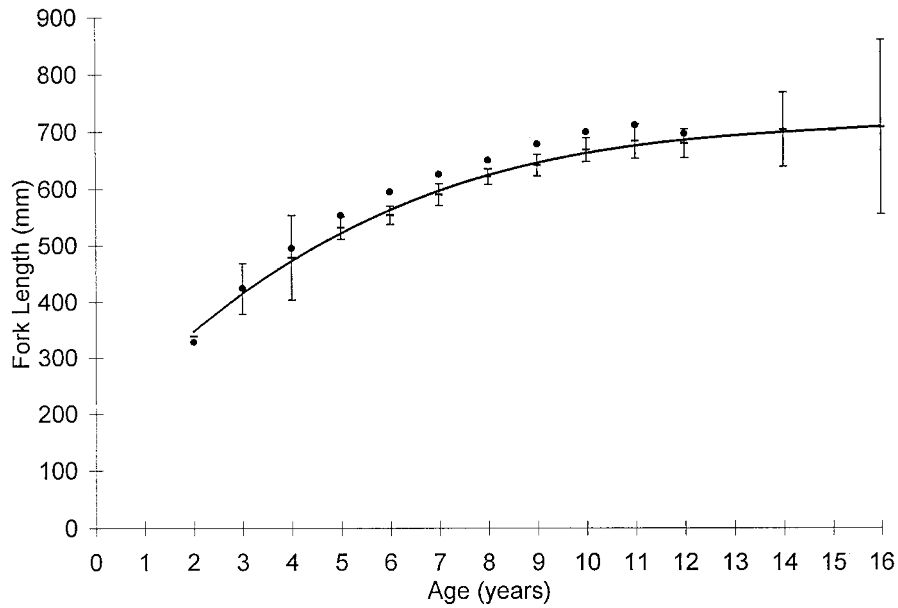

FIGURE 3.—Mean fork length at age (±95% confidence intervals) of 200 shovelnose sturgeon captured between 15 October 1995 and 12 March 1997 in the lower Mississippi River. Line depicts the von Bertalanffy growth curve; dots depict mean fork lengths from Helms (1974).

to age, but older individuals were more challenging. Many individuals had apparent false annuli that could have been caused by high summertime temperatures. However, Swain et al. (1980) alluded to the presence of false annuli in upper Mississippi River shovelnose sturgeon, and Keenlyne and Jenkins (1993) reported double annuli in pallid sturgeon fin ray sections, so this may be normal for this genus. Also, older, presumably slower-growing, fish often had several annuli clumped near the ray margin that were difficult to count accurately. Our final age estimates indicated that initial estimates were often too low. This is consistent with Rien and Beamesderfer (1994), who found that age of white sturgeon *Acipenser transmontanus* was often underestimated.

We did not find any studies that fitted a von Bertalanffy growth equation to shovelnose sturgeon growth data. Dadswell (1979) reported a growth coefficient (K) of 0.047–0.063 for shortnose sturgeon *Acipenser brevirostrum,* and Kohlhorst et al. (1980) reported a K of 0.040 for white sturgeon. Our estimated K of 0.213 is three to five times greater, which one would expect because shortnose and white sturgeons reach sexual maturity at 10–25 years (Dadswell 1979; Chapman 1989), compared with 5–7 years for shovelnose sturgeon. Likewise, our asymptotic length (L_∞) of 730 mm is probably reasonable for this population.

Missouri River populations in South Dakota and Montana were composed of old individuals (8–33 years), with growth rates less than (Zweiacker 1963) or comparable with (Berg 1981) those observed in this study. In contrast, the shovelnose sturgeon population in the Mississippi River bordering Iowa is composed mostly of young individuals (2–13 years) with higher growth rates than observed in this study (Helms 1974; Figure 3).

The total annual mortality of shovelnose sturgeon aged 7 years or older was 20% in our study. We did not attempt to determine causes of mortality, but conversations with commercial fishers suggest that shovelnose sturgeon are not usually targeted. Nonetheless, markets for their eggs exist, and commercial harvest in Arkansas from 1980 to 1992 ranged from 9,189 to 22,047 kg (Robison and Buchanan 1988; Keenlyne 1997). Directed harvest of Shovelnose sturgeon and the fate of incidentally captured fish have not been studied in Mississippi, but it is likely that fishing mortality is a substantial component of total mortality estimated in this study.

Shovelnose sturgeon populations in healthy habitats can probably withstand total annual mortality rates of 20% or more for age-classes of 5 years and older. Mean annual harvest of shovelnose sturgeon in the Mississippi River bordering Iowa was 6,591 kg (range, 2,383–9,432 kg) for the years

1960–1973, and total annual mortality of that population was 63% for ages 5–13 (Helms 1974). In 1992, an estimated 34,603 kg of shovelnose sturgeon were harvested from the Mississippi River in Iowa (Keenlyne 1997), which suggests that shovelnose sturgeon populations can withstand mortality rates considerably higher than our estimate of 20%. It also indicates that demand for upper Mississippi shovelnose sturgeon has increased.

Shovelnose sturgeon reach sexual maturity at a younger age than any other North American chondrostean, except perhaps the Alabama sturgeon *S. suttkusi*. They are also one of the smallest sturgeons in North America and may not become fully vulnerable to commercial fishing gear until after reaching sexual maturity. These attributes may enable shovelnose sturgeon populations to withstand fishing pressure that would quickly deplete other sturgeon species. In contrast to the shovelnose sturgeon, females of the endangered pallid sturgeon may not spawn for the first time until age 17 or older (Keenlyne and Jenkins 1993). Fishes, such as the pallid sturgeon, that reach sexual maturity at old ages are extremely vulnerable to small increases in mortality rates (Boreman 1997). We know that pallid sturgeon are present in the lower Mississippi River, that they are sometimes captured on trotlines (J. Hoover, U. S. Army Corps of Engineers, unpublished data), and that they are similar to shovelnose sturgeon in appearance (Keenlyne et al. 1994). However, we are not aware of any studies investigating incidental mortality of pallid sturgeon in shovelnose sturgeon fisheries. A shovelnose sturgeon population may be able to sustain an annual 20% mortality rate for ages 7 and older, but a pallid sturgeon population probably could not.

Age-classes 5–12 years were well represented in this sample, indicating that recruitment occurred yearly and that a large number of individuals reached sexual maturity (i.e., ages 5–7; (Helms 1974; Farbee 1979). If our sampling sites are representative, then the lower Mississippi River shovelnose sturgeon population may be healthy. However, the population should be studied further to determine factors influencing recruitment, mortality rates of young fish, and causes of mortality in older fish. Age structure and mortality rates indicate that this population is presently being exploited. The potential high commercial value (Becker 1983; Keenlyne 1997) may raise demand enough to reduce shovelnose sturgeon stocks in the lower Mississippi River. An increase in fishing pressure for shovelnose sturgeon could also affect pallid sturgeon populations if steps are not taken to reduce incidental fishing mortality.

Although shovelnose sturgeon may be less vulnerable to human-induced impacts than other sturgeon species, they are not immune, and populations have been greatly reduced or extirpated in several large rivers where they were formerly common (Etnier and Starnes 1993). Furthermore, commercial harvest of shovelnose sturgeon may be increasing in parts of the upper Mississippi River (Helms 1974; Keenlyne 1997), and harvest is unrestricted throughout most of the lower Mississippi River. It would be prudent to limit harvest of shovelnose sturgeon in the lower Mississippi River before populations are overfished (Kirk et al. 1993). Consequently, life history studies and proactive implementation of appropriate harvest restrictions should be undertaken in the lower Mississippi River.

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