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Age Estimation for Shovelnose Sturgeon: A Cautionary Note Based on Annulus Formation in Pectoral Fin Rays

KASEY W. WHITEMAN AND VINCENT H. TRAVNICHEK*

Missouri Department of Conservation, Resource Science Center, 1110 South College Avenue, Columbia, Missouri 65201, USA

MARK L. WILDHABER, AARON DELONAY, DIANA PAPOULIAS, AND DONALD TILLETT

U.S. Geological Survey, Biological Resources Division, Environmental and Contaminants Research Center, 4200 New Haven Road, Columbia, Missouri 65201, USA

Abstract.—Numerous studies have examined the age and growth of shovelnose sturgeon *Scaphirhynchus platorynchus*, but only one study attempted to validate age estimation techniques. Therefore, our objective was to use marginal increment analysis to validate annulus formation in pectoral fin rays of shovelnose sturgeon collected from the Missouri River. We also compared the precision of age estimates between two different readers. Marginal increment distance indicated that for most of the populations an opaque band was laid down in pectoral fin rays during the summer. However, opaque bands were formed throughout the year in some individuals, which could be problematic when using fin rays for age estimation. The agreement of age estimates by two readers for shovelnose sturgeon was only 18%, and differences in ages between the two readers increased for older fish. The presence of split annuli, false annuli, spawning bands, imbedded rays, and deteriorating sections made individual growth rings difficult to separate. Our findings verified that opaque bands are formed annually during the summer in the pectoral fin rays of most shovelnose sturgeon, but some individuals form opaque bands during other times. Pectoral fin rays will probably continue to be the most practical method of age estimation in shovelnose sturgeon, but ages estimated by this method should be used with caution.

The shovelnose sturgeon *Scaphirhynchus platorynchus*, the smallest of eight North American sturgeon species, is indigenous to the Mississippi River basin (Bailey and Cross 1954; Lee et al. 1980). Although this species is the most widespread of North American sturgeons, distribution and abundance have been reduced over the past 100 years due to habitat alteration, water pollution, and overharvest (Keenlyne 1997). Shovelnose sturgeon flesh is not important commercially, being valued at only US$0.75/kg; the commercial value of its eggs for caviar, however, exceeds $44/kg and retails under the name hackleback caviar for $462-$714/kg. Commercial exploitation of shovelnose sturgeon could increase dramatically if the sturgeon populations in the Caspian, Black, and Adriatic seas collapse (Birstein 1993).

Heightened demand would increase commercial harvest pressure, so this fishery must be managed properly. Quist et al. (2002) examined population characteristics and modeled several exploitation rates for shovelnose sturgeon populations in the Missouri River. Age and growth data are essential for implementing regulations to properly manage any fishery, and many models such as the one used by Quist et al. (2002) require age and growth information. The most practical technique for estimating sturgeon age uses pectoral fin rays because they can be easily collected without damaging the fish (Currier 1951) and seem to be more reliable than other structures (Brennan and Cailliet 1989).

Beamish and McFarlane (1983) discussed the importance of validating age estimation techniques and indicated that many investigators continue to neglect age validation despite the importance of accurate age determination. Incorrect age assignment can lead to errors in estimating growth and mortality, and inaccurate year-class assignment will bias estimates of recruitment. Age and growth of shovelnose sturgeon has been well-studied, primarily via pectoral fin ray sections (Zweiacker 1967; Carlander 1969; Helms 1974; Carlson et al. 1985; Morrow et al. 1998; Quist et al. 2002; Everett et al. 2003), yet only one of these studies attempted to validate, using length frequency histograms, age estimation (Helms 1974). Everett et al. (2003) assumed that opaque bands found in pectoral fin ray sections of shovelnose sturgeon were laid down in the summer, translucent bands were laid down in the winter, and one pair of opaque and translucent bands was equal to 1 year

* Corresponding author: vince.travnichek@mdc.mo.gov

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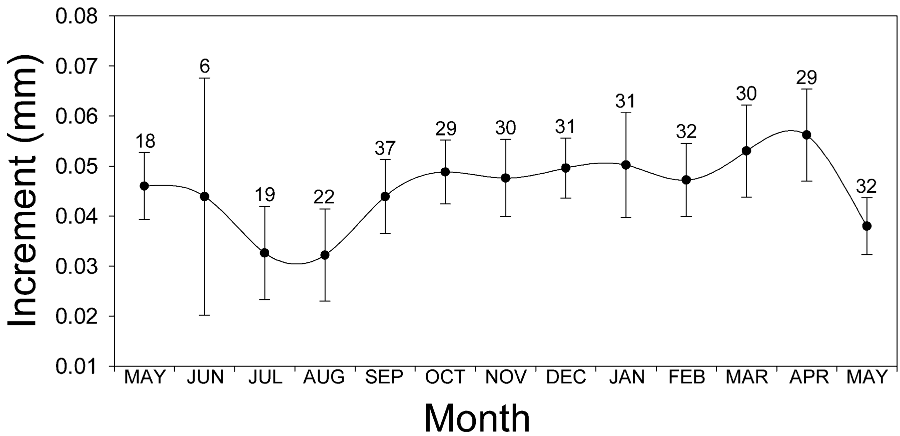

FIGURE 1.—Mean marginal increment distance by month for pectoral fin ray annuli of shovelnose sturgeon collected from the Missouri River, May 2001 to May 2002. Bars indicate 95% confidence intervals. Numbers indicate sample size for each month.

of growth. Two rings may form annually in sturgeon (Sokolov and Malyutin 1978), and slow-growing fish do not appear to form a distinct growth zone each year (Rien and Beamesderfer 1994).

Despite sectioned pectoral fin rays being widely accepted for estimating sturgeon age, only two studies have attempted to validate fin rays as an acceptably accurate technique for estimating sturgeon age. An oxytetracycline marker validated annular rings in pectoral fin rays of white sturgeon *Acipenser transmontanus* (Rien and Beamesderfer 1994) and lake sturgeon *Acipenser fulvescens* (Rossiter et al. 1995), but such periodicity in ring deposition has never been validated for shovelnose sturgeon. Therefore, our objective was to use marginal increment analysis to validate annulus formation in shovelnose sturgeon pectoral fin rays. We also compared precision of age estimates between two different readers.

Methods

Shovelnose sturgeon were collected from the Missouri River (river kilometers 244–276) near Jefferson City, Missouri, each month from May 2001 through May 2002 with stationary gillnets, drifting trammel nets, and hoop nets. Fork length was measured for each fish, and a marginal pectoral fin ray was collected from each fish. Once collected, pectoral fin rays were air-dried for 3 weeks and then cut using a Buehler Isomet low-speed saw set at a speed of five. Four sections of varying thicknesses (406 μm, 305 μm, 457 μm, and 406 μm) were taken starting 1–2 mm proximal to the start of the curve on the ray. This portion of fin ray generally produced the most readable sections. Sections were checked for clarity, and subsequent 406-μm sections were taken if needed. Sections were examined and aged on a microprojector (47× magnification). Alcohol was added to the slide and fin ray section to improve clarity of the sections.

A subsample (N = 70) of sections was examined by two different readers to evaluate agreement of age estimates. When discrepancies occurred, both readers met to resolve differences. The distance from the outer edge of the last opaque band to the margin of each fin ray was measured to determine the margin increment. Each opaque band was assumed to be 1 year of growth. Marginal increment of the hyaline zone was measured for each pectoral fin ray to validate that opaque bands were annuli and determine the time of annulus formation (Casselman 1987). Mean increment distance was calculated and plotted for each month. One-way analysis of variance (ANOVA) and Bonferroni multiple comparison tests were used to determine if margin increments differed significantly among months. Statistical comparisons were conducted with Statistix software (Analytical Software 1998).

Results and Discussion

We collected 346 shovelnose sturgeon from the Missouri River. Marginal increment was highest during the month of April, and monthly mean increment distance indicated that a single opaque band was laid down once each year in pectoral fin rays of most shovelnose sturgeon (Figure 1). Mean marginal increment declined during May, suggesting that annuli started to form at this time.

Minimum marginal increment values were generally found during July and August when annulus formation was completed. Everett et al. (2003) indicated that formation of opaque bands found in pectoral fin ray sections of shovelnose sturgeon were probably laid down in the summer, and our results corroborate this assumption. Rien and Beamesderfer (1994) found similar results for white sturgeon from the Columbia River; fish less than 850 mm formed annuli by July.

Visual inspection of mean marginal increments for each month indicated that annulus formation occurred in July and August. However, one-way ANOVA showed that marginal increment distance did not vary significantly among months because of high variation within months (F = 1.67; df = 12, 334; P = 0.071; Figure 1). Marginal increment distance was highly variable within months, and all months contained at least one individual showing no increment between the opaque band and fin ray edge. This is problematic for using fin rays to estimate age of shovelnose sturgeon. Some individuals could lay down opaque annuli at times outside the summer period when most of the population forms annuli. Conversely, some individuals could lay down a second or false annulus outside of the period when most of the population forms annuli, similar to that reported by Sokolov and Malyutin (1978). Other studies on shovelnose sturgeon reported the presence of false annuli in fin rays (see Morrow et al. 1998). To verify which scenario is occurring, a capture–recapture study utilizing oxytetracycline-marked fish should be conducted similar to that conducted for other sturgeon species (Rien and Beamesderfer 1994; Rossiter et al. 1995).

The two readers agreed in their age estimates for only 18% of the 70 shovelnose sturgeon aged by both. When agreement was relaxed to estimates within 1 year of each other, agreement increased to 46%, within 2 years agreement increased to 73%, and within 3 years agreement increased to 84%. Agreement between the two readers in this study was lower than that observed in other studies on sturgeon, and this may be related to the lack of experience of aging shovelnose sturgeon by both readers. However, both readers spent several days working with a biologist that has aged hundreds of shovelnose sturgeon. Brennan and Cailliet (1989) found 17–31% agreement between two different sets of readers who estimated ages of lake sturgeon, and Rien and Beamesderfer (1994) found 37% agreement between two readers who estimated ages of white sturgeon. However, our results were similar to these studies in that over 80% of ages assigned by two readers were within 3 years of each other.

Agreement between the two readers in our study was greater for ages 15 or younger (25%; 7 of 28 fish) than for ages 16–20 (17%; 6 of 35 fish) or for ages 21 years or older (0%; 0 of 7 fish). Similarly, Rien and Beamesderfer (1994) found agreement between readers to be 48% for white sturgeon ages 15 or younger, 36% for ages 16–20, and 16% for ages 21 and older. Differences in age estimates between the two readers in our study increased for older ages. Average discrepancy in age was 1.6, 1.7, and 4.3 years for ages 15 or younger, ages 16–20, and ages 21 and older, respectively, between the two readers. Discrepancies between readers were due to the difficulty in interpreting annuli. The presence of split annuli, false annuli, spawning bands, imbedded rays, and deteriorating sections made it difficult to separate out each individual growth ring. Also, interannuli spaces were greater near the origin but lessened toward the edge, thereby leading to difficulty in identifying annuli. Similar patterns and difficulties in estimating age have been noted for other sturgeon species (Brennan and Cailliet 1989; Rossiter et al. 1995).

In conclusion, an opaque band found on pectoral fin rays of shovelnose sturgeon appears to form annually, and formation is complete by August. However, false annuli may be present in some individuals of the population because opaque band formation was observed throughout the year in a few individuals. Additionally, agreement between two readers was low in this study, and disagreement increased with fish age. Many external factors can affect growth, and this can cause difficulty in using pectoral fin rays for estimating age in sturgeon (Rien and Beamesderfer 1994; Rossiter et al. 1995). The use of pectoral fin ray sections will probably continue to be the most practical method of age estimation in shovelnose sturgeon. However, ages estimated by this method should be used with caution because imprecision limits interpretation of age frequencies, relative year-class strengths, and estimates of growth and mortality (Rien and Beamesderfer 1994).

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