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# Accuracy and Precision of Age Estimates for Pallid Sturgeon from Pectoral Fin Rays

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*Abstract.*—Accurate age information is critical to the biological understanding and management of most fish species, but particularly for species of concern, such as the pallid sturgeon *Scaphirhynchus albus*. The accuracy and precision of pallid sturgeon age estimates from pectoral fin ray sections has never been established, yet all accumulated age information for the species was collected using this technique. To examine the accuracy and precision of age estimates, 16 pectoral fin ray samples from age-6 pallid sturgeon were obtained from Gavins Point National Fish Hatchery, South Dakota. The fin rays were sectioned, mounted, and independently examined twice by each of two readers. Only 28.1% of the age estimates accurately reflected the known age of the fish. Multiple readings of the same sample by the same reader (within-reader precision) only agreed 25% of the time, differences being as great as 5 years between the two estimates. Between-reader agreement was 46.9%, the two readers' estimates of the same fish differing by as much as 2 years. Because of low accuracy and precision, estimated ages from pallid sturgeon pectoral fin rays should be viewed with caution.

Although the pallid sturgeon *Scaphirhynchus albus* was federally listed as an endangered species in 1990, a limited understanding of the biology of this species has hindered its management and rehabilitation efforts (Dryer and Sandvol 1993). Accurate age information is critical to the biological understanding and management of most fish species. Although some age and growth information has been gathered on the species, this information was inferred from ages estimated from pectoral fin rays (Keenlyne et al. 1992; Keenlyne and Jenkins 1993). The accuracy and precision of age estimates of pallid sturgeon from pectoral fin rays sections has never been established.

Use of fin rays for estimating ages of sturgeon is common (Cuerrier 1951; Helms 1974; Kohlhorst et al. 1980; Keenlyne and Jenkins 1993; Rossiter et al. 1995), but validation of fin-ray age estimates of sturgeon has only been attempted for a few species, mainly by Rossiter et al. (1995) for lake sturgeon *Acipenser fulvescens* and by Rien and Beamesderfer (1994) for white sturgeon *A. transmontanus*. Beamish and McFarlane (1983) asserted that techniques for estimating ages must be validated for each species across its life span if the technique is to be useful. They also note that extrapolation between species is dangerous. No studies have validated the accuracy of ages estimated from pectoral fin rays of pallid sturgeon. The objective of this study was to determine if age estimates from pallid sturgeon fin ray cross sections accurately reflected the true age of the fish. Additionally, precision was examined between readers and between readings from the same reader of age estimates from pallid sturgeon fin rays.

## Methods

Fin ray samples were obtained during the spring from 16 age-6 pallid sturgeon raised at Gavins Point National Fish Hatchery, South Dakota. Growing conditions at the hatchery were held as close as possible to those found in the wild. The primary water source for the facility is Lewis and Clark Reservoir, a main-stem Missouri River reservoir. Lewis and Clark Reservoir is within the historical distribution of the pallid sturgeon. Therefore, the water temperature and chemistry were similar to that found in natural pallid sturgeon habitat. Pallid sturgeon were raised using natural, ambient lighting to mirror natural rearing conditions found in the historical pallid sturgeon range. The fish were raised in circular tanks with low to moderate water flow rate and movement and were fed prepared diets to satiation. With growing conditions similar to those found in the wild, fin ray development and annulus formation was considered to be representative of wild sturgeon.

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Pallid sturgeon used in this study ranged from 470 to 743 mm in fork length. Because all pallid sturgeon were from the same year-class, 17 shovelnose sturgeon *S. platorynchus* of unknown age and varying sizes (522–624 mm in fork length) were obtained from the middle Mississippi River. Shovelnose sturgeon samples were mixed randomly with the pallid sturgeon samples throughout the age estimation process to reduce reader bias. Shovelnose sturgeon age estimates were removed from the study data before analysis.

Handheld pruning shears were used to remove approximately 25 mm of leading edge of the left pectoral fin ray of each sturgeon as close as possible to its articulation with the body. Fin rays were air-dried and approximately 0.5-mm cross-sections were removed using a Beuhler low-speed saw. The three most proximal cross-sections from each fin ray were mounted on glass slides using thermoplastic cement.

Before examination, samples were randomized with the use of a random number table and numbered sequentially with black ink. The samples were then randomized again and renumbered with red ink. Each fin ray was then examined twice by two independent readers in the blind. Both readers had experience with estimating age from scales, otoliths, and spines. Reader 1 was a doctoral candidate who had recently completed age estimates of channel catfish *Ictalurus punctatus*, flathead catfish *Pylodictis olivaris*, and blue catfish *I. furcatus* from spine samples collected over a decade by a midwestern state fisheries agency. Reader 2 was a university research assistant with over a decade of experience estimating age from scales, otoliths, and spines as part of multiyear, grant-funded research projects at a Midwestern university. Readers first examined the samples in order of the black numbers and then reexamined the samples in order of the red numbers. Fin ray cross sections were examined using a binocular dissecting scope with both transmitted and reflected light, depending on which provided best enhancement of the annuli. Cross-sections were coated with glycerol to increase the distinction of annuli. Because of the spring collection date of the fin ray samples, the edge of the fin ray was assumed to represent an annulus.

Accuracy of fin ray ages in pallid sturgeon was examined as percent agreement with the known age of 6 years and a one-sample *t*-test. Precision within readers was examined by the percent agreement between first and second readings and paired-sample *t*-tests. Precision between readers was analyzed by calculating percent agreement, paired-sample *t*-tests, and average percent error (APE) calculated as

$$\text{APE} = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{1}{R}\sum_{i=1}^{R}\frac{|x_{ij} - x_j|}{x_i}\right) \times 100,$$

where $N$ is the number of fish, $R$ is the number of readings per sample, $X_{ij}$ is the $i$th reading of the $j$th fish, and $X_j$ is the mean estimated age of the $j$th fish (Beamish and Fournier 1981). For all statistical tests we set $\alpha = 0.05$.

## Results

Age estimates differed significantly from their known age according to a one-sample *t*-test ($t = -4.306$, df = 63, $P < 0.001$). Of the 64 age estimates from 16 pallid sturgeon, 28% agreed with the known age and 72% were incorrect, the greatest error being 3 years (Figure 1). Ages for 56% of the fin rays were estimated to be within 1 year of the correct age, and 89% were within 2 years (Table 1). Both readers 1 and 2 tended to underestimate, rather than overestimate ages of the pallid sturgeon samples (Figure 1).

First and second age estimates for the same fish by each reader (within reader precision) varied greatly (Table 1). Estimated ages of one fish differed from the true age by 5 years for reader 1 and, for a different fish, by 4 years for reader 2. First and second readings of the same sample by the same reader only agreed 25% of the time. First and second readings did not differ significantly from each other (paired $t = -1.464$, df = 15, $P = 0.1654$ for reader 1; $t = 0.131$, df = 15, $P = 0.898$ for reader 2).

Precision between readers was also low, estimates of the same fish differing between readers by up to 2 years. Only 46.9% of the estimates of the same fish by the two readers agreed (Table 1). Average percent error for estimates by the two readers was 6.17 (Table 2). Readings by the two independent readers, although not significantly different from each other, were approaching significance (paired $t = -1.487$, df = 32, $P = 0.147$).

## Discussion

Ages estimated from pectoral fin ray sections of pallid sturgeon were not accurate, producing only 28% accuracy and up to 4 years of variation. Therefore, use of this technique to separate cohorts and examining year-class strength in pallid sturgeon populations would be unreliable. Bradford (1991) demonstrated that any error in age esti-

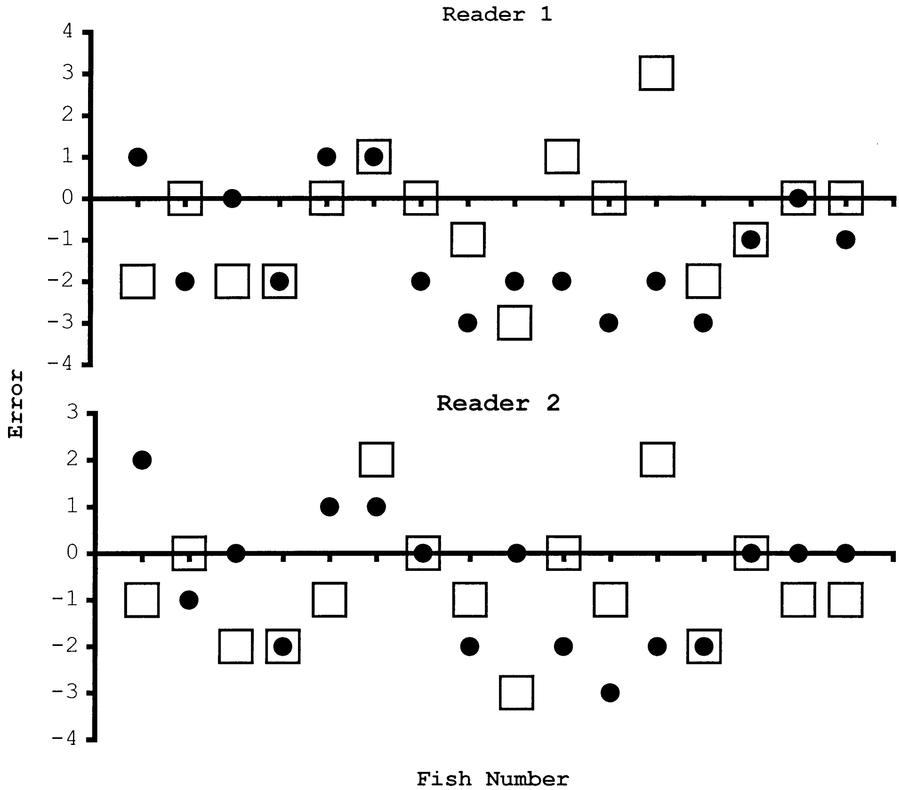


FIGURE 1.—Aging errors for two readers of pallid sturgeon pectoral fin rays. Each ray was read twice (dark circles and open squares) by each reader in blind tests (i.e., readers were unaware of their previous age estimates or of the other reader's estimates).

mates could also have severe effects on recruitment analysis from sequential population analysis. Rien and Beamesderfer (1994) found that age estimates of white sturgeon marked with oxytetracycline were accurate for only 46%, 28%, and 38% of the fish at large for 1, 2, and 3 years, respectively. However, Rossiter et al. (1995) reported 80–100% accuracy in time-at-large-estimates for lake sturgeon. Fin rays from lake sturgeon may provide more accurate age estimates than fin rays of white or pallid sturgeon. Differences in accu-

TABLE 1.—Accuracy ($N = 64$), between-reader precision ($N = 32$), and within-reader precision ($N = 16$) of fin ray age estimates derived from counts of annuli on pectoral fin ray cross sections from 16 age-6 pallid sturgeon. Between-reader precision represents the extent of agreement for ages assigned by two independent readers for the same structure. Within-reader precision represents the extent agreement for ages assigned by the same reader for the same structure during two independent examinations.

| Classification of estimates | Accuracy (%) | Between-reader precision (%) | Within-reader precision (%) | |
|---|---|---|---|---|
| | | | Reader 1 | Reader 2 |
| Correct | 28.1 | 46.9 | 25.0 | 25.0 |
| Within 1 year | 56.2 | 93.8 | 50.0 | 56.3 |
| Within 2 years | 89.0 | 100 | 75.0 | 81.3 |
| Within 3 years | 100 | | 93.8 | 93.8 |
| Within 4 years | | | 93.8 | |
| Within 5 years | | | 100.0 | |

TABLE 2.—Percent agreement between readers (as defined in Table 1) and average percent error (APE) from pallid sturgeon and white sturgeon pectoral fin ray aging studies.

| Sturgeon species | Percent agreement | | | | APE | Maximum estimated age |
|---|---|---|---|---|---|---|
| | Complete | Within 1 year | Within 2 years | Within 3 years | | |
| Pallid[a] | 47 | 94 | 100 | | 6.17 | |
| White[b] | 37 | 68 | 83 | 91 | 5.89 | 9 |
| White[c] | 17–31 | 57–63 | 77–84 | | | 104 |
| White[d] | 32 | 74 | 95 | | | >20 |

[a] Current study.
[b] Rien and Beamesderfer 1994.
[c] Brennan and Cailliet 1989.
[d] Kohlhorst et al. 1980.

racy reported between species underscores the importance of validating age estimation techniques for every species (Beamish and McFarlane 1983).

We found that between-reader precision was higher than in previous studies of white sturgeon. Although Rossiter et al. (1995), in studies of lake sturgeon age estimates, did not provide measure precision and confounded within-reader and between-reader precision, their results suggest higher levels of both types of precision than we observed in our study. As in the discussion of accuracy, these studies indicate that validating aging techniques for individual species is necessary because precision varies among sturgeon species. Low between-reader precision, as observed in this study, may indicate that readers are using different criteria for determining an annulus, so precision may be improved with further training of the readers. However, Kohlhorst et al. (1980) tried to improve low between-reader precision of white sturgeon aging by setting criteria for annuli determination, but they failed to substantially increase between-reader precision. Given the high within-reader variation of age estimates we observed for pallid sturgeon, recognition of annuli in pallid sturgeon fin ray samples was difficult and inconsistent at best. Further study is needed to determine if such criteria could improve annulus recognition and enhance between-reader precision of age estimates of pallid sturgeon. However, low accuracy and low within-reader precision would probably hinder such an increase in between-reader precision.

Low accuracy and precision of ages estimated from pectoral fin rays of pallid sturgeon pose an interesting dilemma for pallid sturgeon management and research. Pectoral fin rays are the only aging structure, currently known, that can be removed from the endangered sturgeon in a nonlethal manner. If further training of readers cannot increase low accuracy and precision, gathering of accurate pallid sturgeon age information in a nonlethal manner may not be possible. Until further research can examine this possibility, all age information of pallid sturgeon inferred from pectoral fin rays should be viewed cautiously. In addition, because of the variation of precision and accuracy of age estimates of various sturgeon species, pectoral fin ray age estimation techniques need to be validated for each sturgeon species being studied by these methods.

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## References

Beamish, R. J., and D. A. Fournier. 1981. A method for comparing the precision of a set of age determinations. Canadian Journal of Fisheries and Aquatic Sciences 38:982–983.

Beamish, R. J., and G. A. McFarlane. 1983. The forgotten requirement for age validation in fisheries biology. Transactions of the American Fisheries Society 112:735–743.

Bradford, M. J. 1991. Effects of aging errors on recruitment time series estimated from sequential population analysis. Canadian Journal of Fisheries and Aquatic Sciences 48:555–558.

Brennan, J. S., and G. M. Cailliet. 1989. Comparative age-determination techniques for white sturgeon in California. Transactions of the American Fisheries Society 118:296–310.

Cuerrier, J. P. 1951. The use of pectoral fin rays for determining age of sturgeon and other species of fish. Canadian Fish Culturist 11:10–18.

Dryer, M. P., and A. J. Sandvol. 1993. Recovery plan for the pallid sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver.

Helms, D. R. 1974. Age and growth of shovelnose sturgeon, *Scaphirhynchus platorynchus* (Rafinesque), in the Mississippi River. Proceedings of the Iowa Academy of Science 81:73–75.

Keenlyne, K. D., E. M. Grossman, and L. G. Jenkins. 1992. Fecundity of the pallid sturgeon. Transactions of the American Fisheries Society 121:139–140.

Keenlyne, K. D., and L. G. Jenkins. 1993. Age at sexual maturity of the pallid sturgeon. Transactions of the American Fisheries Society 122:393–396.

Kohlhorst, D. W., L. W. Miller, and J. J. Orsi. 1980. Age and growth of white sturgeon collected in the Sacramento–San Joaquin estuary, California: 1965–1970 and 1973–1976. California Fish and Game 66: 83–95.

Rien, T. A., and R. C. Beamesderfer. 1994. Accuracy and precision of white sturgeon age estimates from pectoral fin rays. Transactions of the American Fisheries Society 123:255–265.

Rossiter, A., D. L. G. Noakes, and F. W. H. Beamish. 1995. Validation of age estimation for the lake sturgeon. Transactions of the American Fisheries Society 124:777–781.