Robert W. Starkey
Dennis L. Scarnecchia

Age and Growth of Channel Catfish in the Lower Yellowstone River, Montana

Abstract

Channel catfish (Ictalurus punctatus) *provide a significant rod and hoop net sport fishery in the Lower Yellowstone River, Montana. In order to obtain age and growth information for fish stock assessment, lengths, weights, and pectoral fin spines from 120 fish were used to back-calculate length-at-age and to fit von Bertalanffy growth curves. Fish ranged in age from 3 to 21 years old. A 300-mm long fish was age-4, a 450-mm fish was age-8, and a 700-mm fish age-14. Maximum observed age of this stock was higher than nearly all other stocks in the literature, and comparable to fish from the Tongue River, a nearby tributary. Growth rates of the stock were also slower than for most stocks. Based on a minimum quality size for anglers of 41 cm, a quality-sized Yellowstone River channel catfish was about age-7.*

Key words: Fish ecology, channel catfish, Ictaluridae, *Ictalurus punctatus*, Yellowstone River, Montana

Introduction

Channel catfish *(Ictalurus punctatus)* inhabit the lower Yellowstone River, a large, turbid, free-flowing river traversing eastern Montana and extreme western North Dakota. The species supports an angling and recreational hoop net fishery in Montana. Although extensive research on the biology and ecology of channel catfish has been conducted (Carlander 1969; Hesse et al. 1982), little information is available for stocks in the extreme northwestern portion of the species' native range. The channel catfish is primarily a warmwater species, and size-at-age and longevity in this extreme portion of their range probably differs from more southerly latitudes. Channel catfish in the Tongue River, a Yellowstone River tributary, occasionally achieved lengths of 750 mm and 19 years of age (Elser et al. 1977). Fish of ages 10 to 15 were common. In contrast, Carlander (1969) reviewed numerous age and growth studies and found only one stock, in Quebec (Magnin and Beaulieu 1965), where fish exceeded age-13. One fish was estimated to be age-22. Vladykov (1951; cited in Magnin and Beaulieu 1966) reported a fish from that province estimated to be nearly age-40. Carlander (1969) also observed that the faster growing stocks tended to be in the southern portion of the species' range.

Our objectives were to (1) determine the size-at-age, maximum age and growth rates of channel catfish from the Yellowstone River, and (2) compare these results to those of stocks from other rivers in the species' range. Differences in age and growth between Yellowstone River fish and those of other locations may necessitate different management strategies. Information collected at this time, when harvest rates

Robert W. Starkey, University of Arkansas, Pine Bluff, P. O. Box 4912, Pine Bluff, AR 71611
Dennis L. Scarnecchia, Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83843-1136

are thought to be low, may be useful in the future when harvest rates can be expected to increase.

Methods

One hundred twenty channel catfish were collected in May and June 1992 from angler creels and hoop net catches at Intake, a low-head irrigation diversion dam on the Yellowstone River, 27 km downriver from Glendive, Montana. Total lengths and weights were recorded, and pectoral spines were removed for age determination. Sex was undetermined for most of the sample so data were not analyzed separately by sex.

The relation between total length (L) and weight (W) was expressed as $W = aL^b$ where a and b are parameters (Sparre et al. 1989). The length-weight relation was compared to a standard length-weight relation for the species (Anderson 1980) to assess if Yellowstone River catfish were plumper or thinner than fish from other populations.

Spines were sectioned (Marzolf 1955) using a Buehler Isomet low-speed saw. Two sections per spine were cut at 0.6350 mm thickness and mounted on a microscope slide using transparent nail polish. Nail polish allowed for a quick, permanent mount which did not hinder microscopic examination.

Annual marks (annuli), on the spine sections were enumerated (Appelget and Smith 1951) using a Biosonics Optical Pattern Recognition System (OPRS). Annuli appeared as opaque bands. Luminosity plots on the OPRS were used to detect questionable or false annuli. False annual marks were distinguished as less distinct and less luminous bands. After age was determined, distances were measured along a standard axis from the center of the spine to each annulus and to the edge of the spine section.

The relation between spine radius (S) and total length (L) was fitted with a linear model $S = a_1 + a_2L$ and a quadratic model $S = a_3 + a_4L + a_5L^2$, where a_i are parameters. The quadratic model was used in back-calculation. Back-calculated lengths were obtained using the scale-proportional hypothesis (SPH) method as described by Francis (1990).

Back-calculated lengths-at-age were compared with lengths-at-age at the time of capture by development of von Bertalanffy growth curves. The generalized von Bertalanffy growth curves were expressed as $L_t = L_\infty(1-e^{-K(t-t_0)})$, where L_t is the length at age t, L_∞ is the expected length of an infinitely old fish, K is the growth coefficient or curvature parameter (Moreau 1987; Sparre et al. 1989), and t_0 is the time when length is theoretically 0. A growth curve was also fitted by setting $t_0 = 0$, i.e., forcing the curve through the origin. Weight-converted von Bertalanffy growth curves were calculated based upon the expression $W_t = W_\infty (1-e^{-k(t-t_0)})^b$ where b is the parameter in the relation between length and weight.

To investigate if any tendency existed for back-calculated lengths to be less for samples obtained from older fish than for younger fish (Lee's phenomenon; Tesch 1971), von Bertalanffy curves were also fitted separately for fish greater than age-7 (called old fish) and for fish age-7 and younger (called young fish). Confidence intervals were compared to evaluate differences ($P<0.05$ for significance). All curve fitting was conducted using Statistical Analysis Systems (SAS) Version 6.11 (SAS Institute, Inc. 1990).

Length-at-age and longevity data from other studies were obtained from Carlander (1969), Hesse (1982) and Hesse et al.(1982) in order to compare the Yellowstone River channel catfish to those in other localities.

Results

The relation between length (mm) and weight (g) was given by the expression $W = 7.32(10^{-7})L^{3.40260}$. A 40-cm long fish thus weighed 0.5 kg and a

70-cm long fish 3.5 kg (Fig. 1). Weight of Yellowstone River fish for a given length was less than for a standard (benchmark) population (Anderson 1980); Yellowstone River fish 30 cm and 60 cm total length weighed 196 g and 2076 g respectively versus 242 g and 2293 g for fish in the standard population.

The channel catfish in our sample ranged from 3 to 21 years old. Although the sample of fish was not random, fish age 10 or older constituted 22 percent of the sample.

The relationship between fish length (L) and spine radius (S) was adequately described by a linear relation $S = 117.00105 + 0.44301L$ ($r^2 = 0.87$; $P<0.0001$; Fig. 2) but was somewhat better described by a quadratic expression $S = 8.21525 + 0.96294L - 0.00054L^2$ ($r^2 = 0.90$; $P<0.0001$; Fig. 2). The quadratic expression was therefore used in back-calculation. Back-calculated lengths-at-age were expressed by the von Bertalanffy growth equation $L = 1149.4004\,(1-e^{(-0.0573*(Age\,-0.3269))})$; (Fig. 3). Length-at-age estimates were higher based on actual lengths and ages of fish caught than on back-calculated lengths; the expression developed from fish at time of capture was $L = 1676.0959\,(1-e^{(-0.03456*(age\,+1.2033))})$; (Fig. 3). Based on this equation, a 300-mm long fish was age-4, a 450-mm fish was age-8, and a 700 -mm fish was age-14. The two-parameter growth equation ($t_0 = 0$) had a much lower L_∞ term, but curves were very close over observed fish lengths (Fig. 3). Length-at-age up to age-7 based on back calculations for old fish (>age-7) were significantly less than for fish age-7 or less($P<0.05$; Fig. 3).

The weight-converted von Bertalanffy growth curve for fish at time-of-capture was given by $W_t = 7.32\,(10^{-7})[1676.096(1-e^{(-0.03456*(age+1.2033))})]^{3.40260}$.

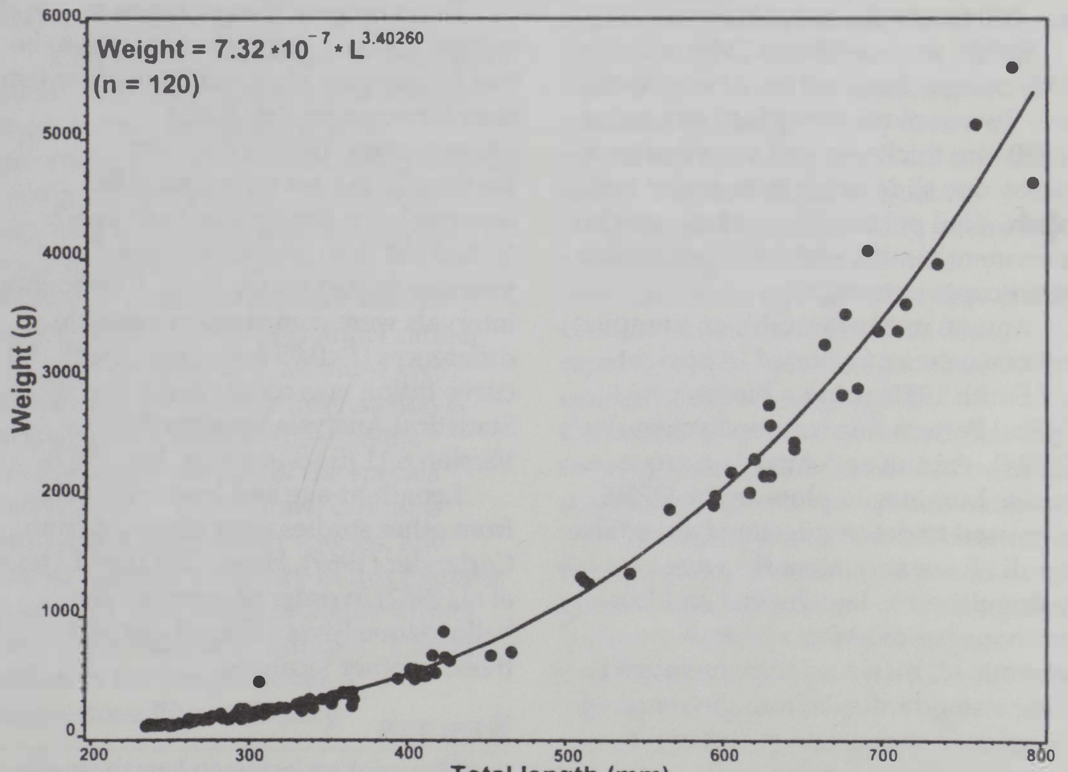

Figure 1. *Length(mm)-weight(g) relationship for Yellowstone River channel catfish, r= 0.99, P<0.01.*

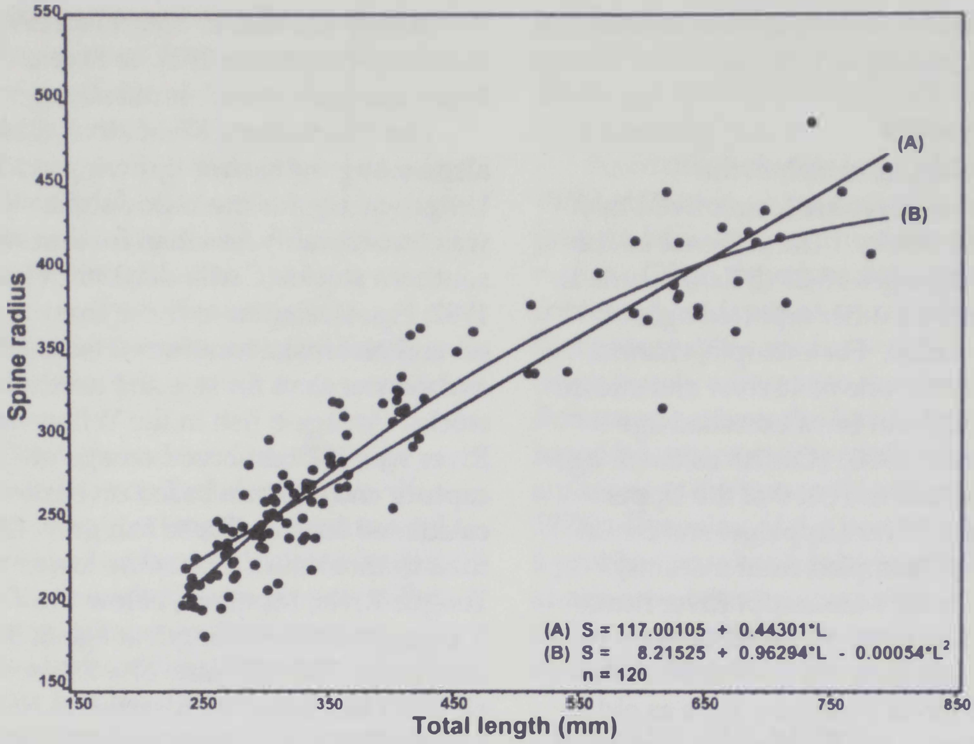

Figure 2. *Relations between spine radius and fish total length fitted with a) a linear model and b) a quadratic model.Spine radius is in Optical Pattern Recognition System standard units.*

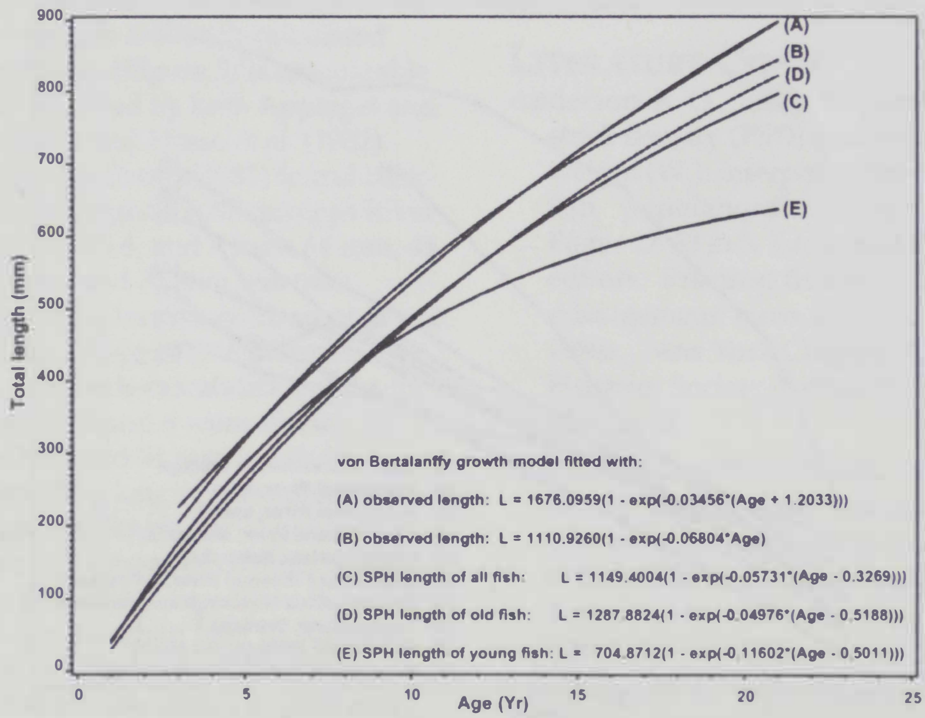

Figure 3. *von Bertalanffy growth curves for Yellowstone River channel catfish based on : a) length at time of capture with t_0 parameter included; b) length at time of capture with $t_0 = 0$ (forced through origin); c) back-calculated lengths at age for all fish; d) back-calculated lengths-at-age for fish greater than age-7; and e) back-calculated lengths-at-age for fish age-7 and under.*

Beyond age-6, there was considerable variation in weight with age.

Discussion

The channel catfish in the Yellowstone River are longer lived than most other stocks. The presence of fish in this study ages 15-21 (5 fish) contrasts with nearly all other reported ages of channel catfish. For example, channel catfish at only one of 44 river and stream sites throughout Iowa exceeded age-9 (Paragamian 1990). Catfish as old as age-12 were found in Pool 9 of the Upper Mississippi River (Appelget and Smith 1951). Fish (sampled from markets) taken from the Mississippi River near Chester, Illinois were as old as age-13 (Raibley and Jahn 1991). Fish from the Missouri River, Nebraska were as old as age-10 (Hesse 1982), although maximum age was not specified. In contrast, Magnin and Beaulieu (1966), reported an age-22 fish from Quebec, and Elser et al. (1977) reported that 25 of 469 fish (5% of the sample) from the Tongue River, Montana, were age-15 or older.

The Yellowstone River stock was also among the slower- growing stocks. Length-at-age for the Yellowstone stock was considerably less than for several southern stocks (Carlander 1969; Hesse 1982; Fig. 4), similar to those from several Nebraska locations (Hesse 1982), and greater than for selected northern stocks. An age-8 fish in the Yellowstone River was 452 mm based on age-at-capture and 406 mm based on back-calculated length. These fish grew faster than channel catfish from the lower Tongue River, Montana, below the T and Y Dam (mean total length at age-8, 389 mm; range 353-437 mm; N = 7; Elser et al. 1977) and faster than catfish in the St. Lawrence River, Canada (mean total length at age-8, 361 mm; Magnin and Beaulieu 1966). Recruitment of fish to the Yellowstone fishery will thus take

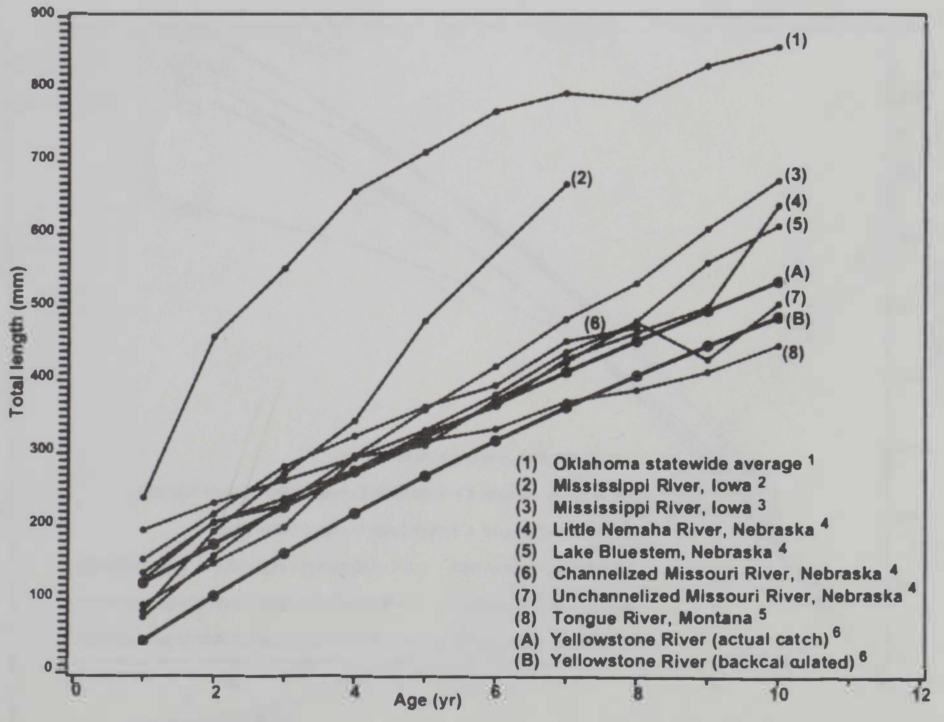

Figure 4. *Size at age of channel catfish from the lower Yellowstone River in relation to other systems. [1]Data from Houser and Bross (1963; cited in Hesse et al. 1982), [2]Data from Harrison (1957, cited in Hesse et al. 1982),[3] Data from Appelget and Smith (1969, cited in Carlander 1969), [4] Data from by Hesse et al. (1982), [5]Data from Elser et al. (1977), [6]Data from this study.*

longer than in more southerly localities. Anderson et al. (1983) considered a 41-cm long catfish to be of quality size; such a fish on the Yellowstone River would be age-7, in Nebraska waters age-6 and in Oklahoma waters age-2 or age-3 (Figure 4). At present, slow growth rates of channel catfish are not a problem in the Yellowstone River because harvest rates are sufficiently low that many large fish remain in the stock.

The differences in length-at-age between the von Bertalanffy growth curves based on length-at-capture and those based on back-calculated lengths may have resulted from growth of fish in spring, after annulus formation. Back-calculated lengths-at-age, which indicate fish length at the time of annulus formation, would be expected to be less than at the time of capture, because fish captured in May and June will have grown since time of annulus formation. The consistent 40-50 mm increment between length-at-age at the time of capture and back-calculated lengths-at-age (Figure 3) is comparable to those reported by both Appelget and Smith (1951) and Hesse et al. (1982). Appelget and Smith (1951) found back-calculated lengths for Mississippi River catfish ages 4,5,6, and 7 to be 64 mm, 45 mm, 50 mm and 31 mm less than corresponding lengths-at-capture. For 8 sites in the Missouri River (Hesse et al. 1982) mean back-calculated lengths for fish ages 3,4,5,and 6 were 49 mm, 43 mm, 44 mm and 71 mm less than corresponding lengths-at-capture. Appelget and Smith (1951) noted that younger age classes of channel catfish usually grew more rapidly in the early part of summer than later in summer, which would increase differences between back-calculated lengths and lengths-at-capture.

Although Yellowstone River catfish were not as plump as a standard (benchmark) catfish (Anderson 1980), the fish did not appear emaciated. Plumpness of river fish would be expected to be less than for fish in ponds, lakes and reservoirs, on which the standard length-weight relation is at least partially based.

As in other studies (e.g., Marzolf 1955), detection of the first annulus proved difficult in many of the older catfish. Often the edge of the lumen contained evidence of an annulus, or the first observable annulus was immediately adjacent to the lumen edge. Bone erosion from the lumen has been noted by others as responsible for loss of annuli near the lumen (Hesse et al. 1978). If erosion of the first annulus was a problem, our back-calculated lengths-at-age are overestimates. Age validation is needed to verify our decisions regarding assigned age.

Acknowledgments

We thank P. Stewart for comments on early drafts of the paper, Y. Lim for assistance with the statistics, and anonymous reviewers for their helpful comments.

Literature Cited

Anderson, R. O. 1980. Proportional stock density (PSD) and relative weight (W_r): interpretive indices for fish populations and communities. Pages 27-33 *in* S. Gloss and B. Shupp, editors. Practical fisheries management: more with less in the 1980s. New York Chapter, American Fisheries Society, Bethesda, Maryland.

Appelget, J., and L. L. Smith. 1951. The determination of age and rate of growth from vertebrae of the channel catfish, *Ictalurus lacustris punctatus*. Transactions of the American Fisheries Society 80:119-139.

Carlander, K. D. 1969. Handbook of freshwater fishery biology. Volume 1. Iowa State University Press, Ames.

Elser, A. A., R. C. McFarland, and D. Schwehr. 1977. The effect of altered streamflow on fish of the Yellowstone and Tongue rivers, Montana.

Montana Department of Natural Resources and Conservation, Water Resources Division, Helena.

Francis, R. I. C. C. (1990). Back-calculation of fish length: a critical review. Journal of Fish Biology 36: 883-902.

Harrison, H. M. 1957. Growth of the channel catfish, *Ictalurus punctatus* (Rafinesque) in some Iowa waters. Proceedings of the Iowa Academy of Science 64:657-666.

Hesse, L. W. 1982. Summary and conclusions. Pages 76-80 *in* L. W. Hesse, editor. The Missouri River channel catfish. Nebraska Game and Parks Commission Technical Series 11, Lincoln.

Hesse, L., B. Newcomb, and Steve Schainost. 1982. Age-growth, length-weight, and condition factors of channel catfish from channelized, unchannelized, and stabilized Missouri River and two major tributaries. Pages 14-19 *in* L. W. Hesse, editor. The Missouri River channel catfish. Nebraska Game and Parks Commission Technical Series 11. Lincoln.

Hesse, L. W., C. R. Wallace, and L. Lehman. 1978. Fishes of the channelized Missouri: age-growth, length-frequency, length-weight, coefficient of condition, catch curves and mortality of 25 species of channelized Missouri River fishes. Nebraska Game and Parks Commission, Nebraska Technical Series; No 4., Lincoln.

Houser, A., and M. G. Bross. 1963. Average growth rates and length-weight relationships for fifteen species of fish in Oklahoma waters. Oklahoma Research Laboratory Report 85, Oklahoma City.

Magnin, E., and G. Beaulieu. 1966 . Divers aspects de la biologie et de l'écologie de la barbue *Ictalurus punctatus* (Rafinesque) du fleuve Saint-Laurent d'après les données du marquage. Trav. Pêcheries Québec 92:277-291.

Marzolf, R. C. 1955. Use of pectoral spines and vertebrae for determining age and rate of growth of the channel catfish. Journal of Wildlife Management 19: 243-249.

Moreau, J. 1987. Mathematical and biological expression of growth in fishes: recent trends and further developments. Pages 81-113 *in* R. C. Summerfelt and G. E. Hall, editors. The age and growth of fish. Iowa State University Press, Ames.

Paragamian, V. L. 1990. Characteristics of channel catfish populations in streams and rivers of Iowa with varying habitats. Journal of the Iowa Academy of Science 97(2):37-45.

Raibley, P. T., and L. A. Jahn. 1991. Characteristics of commercially-harvested channel catfish from areas of the Mississippi river along Illinois:commercial harvest and the 15.0-in. minimum length limit. Journal of Freshwater Ecology 6:363-376.

SAS Institute, Incorporated. 1990. SAS language and procedures: introduction. SAS Campus Drive, Cary, North Carolina. 27513.

Sparre, P., E. Ursin, and S. C. Venema. 1989. Introduction to tropical fish assessment. Part 1-Manual. United Nations Food and Agriculture Organization Fisheries Technical Paper. 306/1. Rome.

Tesch, F. W. 1971. Age in growth. Pages 98-130 *in* W. E. Ricker, editor. Methods for assessment of fish production in freshwaters. Second edition. Blackwell Scientific Publications, Oxford, United Kingdom.

Vladykov, V. D. 1951. Rapport du biologiste. Rapport General Ministere Chasse et Pêcheries, Quebec. 35:65-66.